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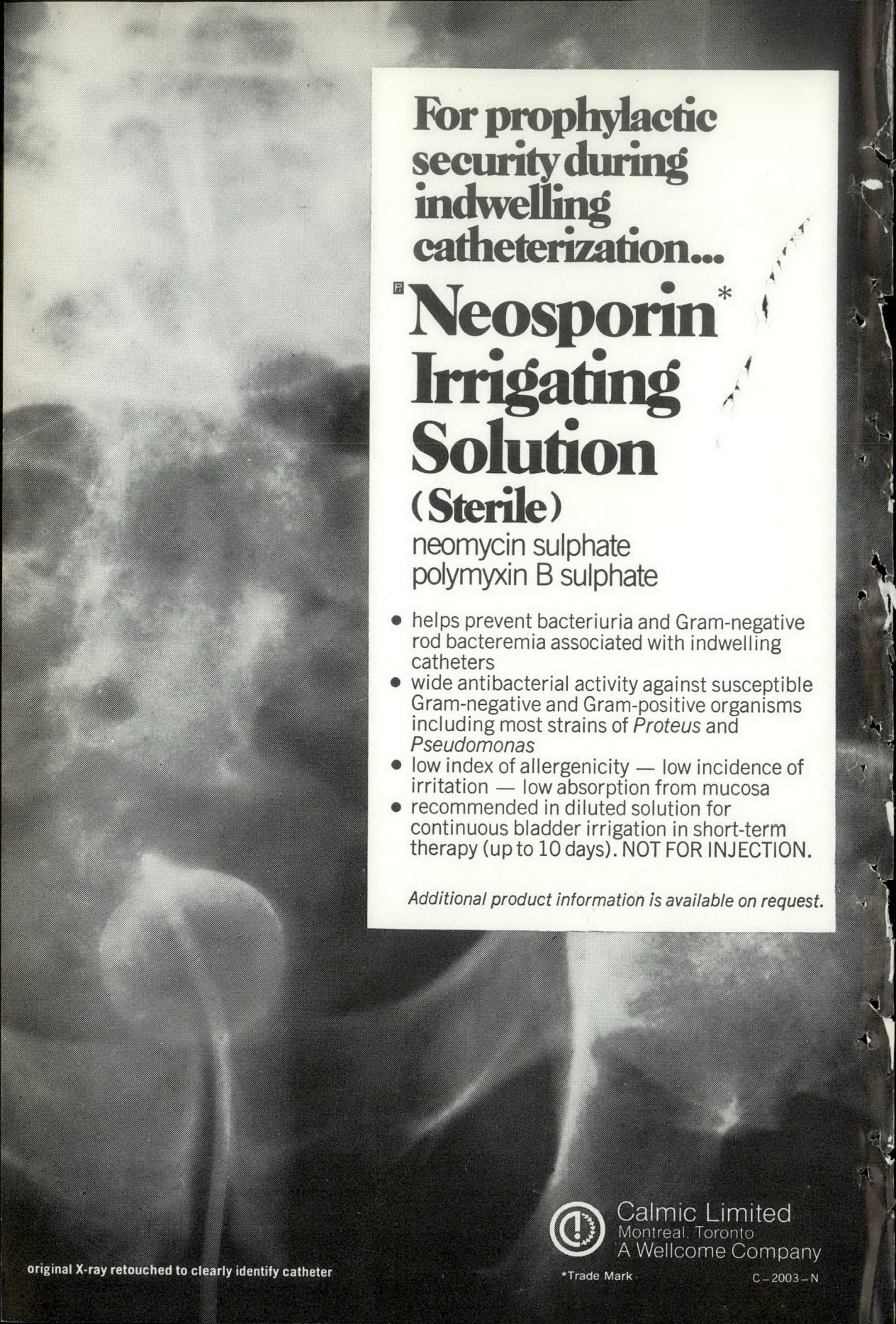

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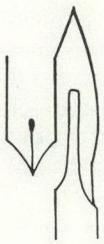

QUILL ON SCALPEL This section provides a medium through which Canadian surgeons can declare themselves, briefly and informally, on the day-to-day affairs of surgery.

TO OUR NEW SUBSCRIBERS— WELCOME

With this issue, the *Canadian Journal of Surgery* assumes a new role. Henceforward, the Journal will be distributed to all Fellows of the Royal College in the Division of Surgery (and any other Fellows of the College who may wish to receive it). The decision to do so is the outcome of several years' activity by the Editorial Board of the Journal, the Canadian Medical Association Publications Committee, and the Royal College of Physicians and Surgeons of Canada.

The Journal was founded in 1957 by Dr. Robert Janes as an organ for the publication of the results of Canadian surgical research, clinical and basic scientific observations and case reports. It has served this function with success during the past 17 years. With this issue, however, it accepts a new and somewhat different responsibility, the obligation to become an agent of continuing education for all surgeons in Canada.

In May 1971, an executive committee of the Journal suggested to the Royal College that the *Canadian Journal of Surgery* become the official scientific organ of the surgeons of the College. The advantages of this arrangement seemed to be manifold. Chiefly, it would further postgraduate surgical education, provide a medium for the presentation of original surgical work to a larger audience, and act as a stimulus for the production of material of sufficiently high quality to satisfy the standards of the Editorial Board. At the annual meeting of the Editorial Board in 1972 it was agreed that negotiations with the Royal College be carried further. Accordingly, the subject was explored at a special meeting in June 1972 between representatives of the Canadian Medical Association and the Royal College of Physicians and Surgeons, and at this time the following positions were agreed upon:

(1) The provision of professional or specialty journals is a function of the College.

(2) The survival of the *Canadian Journal of Surgery* with a change in editorial policy is important and should be ensured.

(3) A Canadian journal of clinical investigation is highly desirable.

(4) There is a need for a central publishing agency in Canada to serve these needs.

Subsequently, a task force established by the Editorial Board at its January 1973 meeting concluded that "affiliation of the Journal with a surgical society . . . is essential, and the Royal College . . . is the obvious choice." The recommendation, supported by the Publications Committee of the Canadian Medical Association, was then presented to the Publications Committee of the Royal College and its Executive and Council. Early in January 1974, a meeting between the two organizations resulted in concurrence that a joint advisory board be established with representation from both the College and the C.M.A. and with the Co-editors as *ex officio* members. Responsibility for the editorial content is to be vested in an Editorial Board appointed by the Royal College of Physicians and Surgeons. This board is to be charged with maintaining a balance that assures the continuation of the bilingual nature of the publication and representation of all aspects of Canadian surgery. The new objectives of the Journal may be summarized as follows: (1) to serve in the effective continuing education of the

Canadian surgical fellowship; (2) to provide the Canadian surgical fraternity with an effective vehicle for the dissemination of their clinical and scientific observations; and (3) to contribute to the extension and upgrading of the international image of Canadian surgery. The Canadian Medical Association will continue to publish the Journal and be responsible for the business aspects of the operation.

Your Co-editors are pleased to accept the charge to move the Journal into new functions in the Canadian surgical scene. We hope that our new subscribers will find this journal attractive and informative and will, whenever they have the inclination, use it as a medium for the expression of ideas, convictions and concern. The editors invite contributions to the section Quill on Scalpel as well as correspondence relating to published material on matters of general interest to surgeons. We welcome you to our list of readers.

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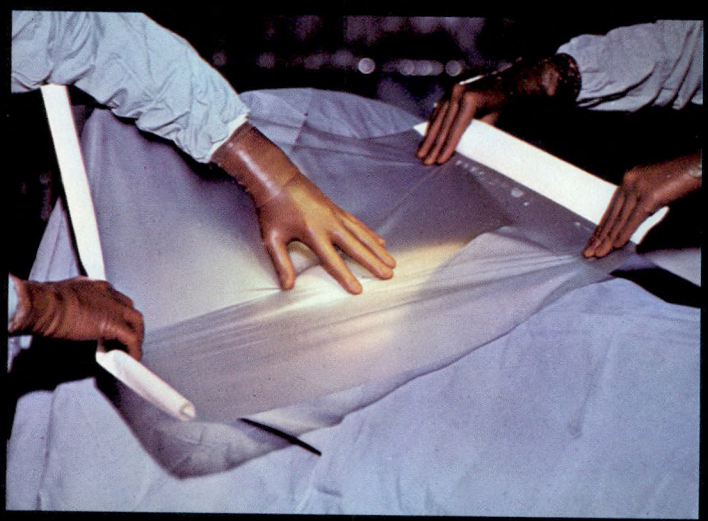

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SURGICAL TECHNIQUE FOR TOTAL ARTIFICIAL HEART REPLACEMENT IN CALVES*

T. NISHIZAWA, M.D.,† D. T. MORRIS, M.Sc.[Eng.], Ph.D.† and
C. M. COUVES, M.D., F.R.C.S.[Edin. & C], F.A.C.S.,‡
Edmonton, Alta.

Summary: We have developed a standardized method of replacing the heart with an artificial device and have applied it to 43 orthotopic heart replacements in experimental animals.

The procedure was developed for the implantation of air-powered hearts of our own design into 80-kg calves. Usually cardiopulmonary bypass was employed but occasionally we used a method utilizing deep hypothermia. Under halothane anesthesia the resected natural heart was replaced with the prosthesis by anastomoses to remnants of the atria and great vessels. After priming, the artificial heart was started and adjusted to provide normal blood flow and heart rate. Postoperatively vital signs and functions were monitored.

Our procedure, once standardized, has allowed us to support the circulation completely for periods up to 33 hours.

Résumé: Nous avons mis au point une technique standardisée pour remplacer le coeur par un dispositif artificiel et l'avons appliquée dans 43 cas de remplacement orthotopique du coeur chez des animaux d'expérience.

Cette méthode a été mise au point pour l'implantation de coeurs artificiels à l'air comprimé (dispositif de notre invention) chez des veaux de 80 kg. Nous avons eu surtout recours à la dérivation cardiopulmonaire, mais nous avons parfois utilisé la méthode d'hypothermie profonde. Sous anesthésie à l'halothane, nous avons remplacé le coeur naturel reséqué par la prothèse, en anastomosant l'appareil avec les moignons des oreillettes et des gros vaisseaux. Une fois la circulation amorcée, et le coeur artificiel mis en marche, on procéda au réglage de la circulation et du rythme cardiaque. Après la transplantation, on surveilla les signes vitaux et les fonctions organiques.

Notre procédé, une fois standardisé, nous a permis de soutenir intégralement la circulation pendant des périodes allant jusqu'à 33 heures.

THE development of a total artificial heart capable of supporting the circulation in man for long periods remains a challenge.[1-4] Although the surgical technique required for the insertion of such a device is not the main limiting factor at the moment, it is essential to have a standardized, uncomplicated method of replacing the heart with an artificial device. This paper describes our method of inserting the total artificial heart in calves.

MATERIALS AND METHODS

Artificial Heart

The prosthetic heart we have devised has been described previously.[3, 5, 6] Both sac-type and diaphragm-type air-driven artificial hearts were used as replacements for the natural heart in animals (Figs. 1 and 2).

Animal and Preoperative Preparation

Calves weighing between 65 and 90 kg were fasted except for water and milk for 48 hours before operation. Penicillin G (KaPen, Pfizer), two million units, was given intramuscularly on alternate days for one week before the experiment. Blood for transfusion was obtained from a local slaughterhouse and stored in ACD containers (anticoagulant citrate phosphate dextrose solution) to which one million units of penicillin per litre of blood was added. Triflupromazine, 0.2 mg/kg, and atropine, 0.02 mg/kg, were given intramuscularly to the animal for premedication.

Anesthesia

Thirty minutes after premedication anesthesia was induced with halothane. A conical face mask and partial rebreathing system with 2% to 3% halothane and 7 to

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Supported by a grant from the Alberta Heart Foundation.

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Reprint requests to: Dr. D. T. Morris, Bio-Medical Engineering Services Ltd., 14710 - 112th Avenue, Edmonton, Alta. T5M 2T9.

10 l/min of oxygen were used. The animal was then placed on its back on the operating table and an endotracheal tube inserted. Before the chest was opened, anesthesia was maintained with 0.1% to 1.5% halothane with spontaneous respiration. Once the chest was opened, the lungs were mechanically ventilated by an Engstrom respirator model 200. The tidal volume was set at 750 ml with a respiratory rate of 18 to 20/min.

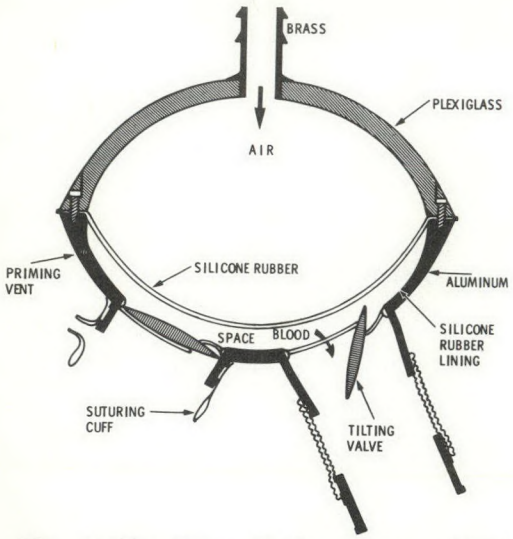

Fig. 1.—The latest diaphragm-type artificial heart is powered by an extracorporeal supply of compressed air. Each ventricle can pump 8 l at 95 beats per minute. Ventricle valve holders and arterial connectors are all lined with Silastic.

Fig. 2.—Each side of the artificial heart is separate and weighs 135 g. Dacron graft arteries and atria simplify anastomosis to the natural vessels.

Establishment of Cardiopulmonary Bypass

The surgical field was shaved, washed with 3% hexachlorophene and painted with 10% providone-iodine NF. The left external jugular vein and carotid artery were exposed for later insertion of cardiopulmonary bypass cannulas. The left subscapular artery and vein were exposed and used for arterial pressure monitoring and for an infusion line. The chest was entered through a midline sternotomy. Tapes were passed around the superior vena cava, inferior vena cava, azygous vein, hemiazygous vein, pulmonary artery and the aorta. Heparin, 4 mg/kg, was given intravenously before insertion of the venous cannulas. A no. 28 Bardic catheter was inserted into the left external jugular vein and positioned in the superior vena cava. A no. 40 Bardic catheter was inserted into the inferior vena cava through the right atrial appendage. A no. 20 Bardic catheter placed in the left common carotid artery was used for arterial inflow.

A Bentley or a Travenol adult disposable oxygenator with a Sarns roller pump was used for cardiopulmonary bypass (Fig. 3). The oxygenator and circuit were primed with 1,500 to 2,000 ml of either 5% dextrose in water or Ringer's solution providing a hemodilution factor of 16% to 21%. Flow rates of approximately 60 ml/kg/min were achieved. The total bypass time was between 60 and 90 minutes. During cardiopulmonary bypass the lungs were manually inflated with a pressure of 30 cm H_2O every 10 minutes. Ventilation was reinstituted with 100% oxygen about five min-

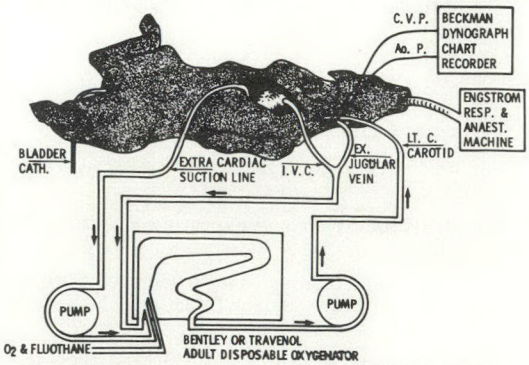

Fig. 3.—The cardiopulmonary bypass technique was used for 40 out of 43 implantations.

utes before the start of artificial heart pumping.

Hypothermia as an Alternative to Cardiopulmonary Bypass

Thirty minutes after premedication with triflupromazine, 0.3 mg/kg and atropine, 0.015 mg/kg, halothane was used for induction and intubation. The anesthetic level was maintained at the third stage of anesthesia during cooling. Catheters for arterial and venous pressure monitoring, blood sampling and fluid administration were inserted through the femoral vessels. Electrodes for electrocardiogram and electroencephalogram and thermister probes for mid-esophageal and mid-rectal temperatures were positioned. The animal was then immersed in a tub with ice and water in the kneeling position. Rheomacrodex 10% (low-molecular-weight dextran), 10 ml/kg, was given intravenously during the cooling period when the rectal temperatures were between 35° and 28° C. At 28° C rectal temperature, triflupromazine, 0.3 mg/kg, and heparin, 1 mg/kg, were given intravenously. After the body temperature had fallen below 28° C the animal was ventilated manually and halothane was decreased to 0.3% to 0.5%. Cooling was terminated at a rectal temperature between 24° and 21° C. The animal was hyperventilated to produce respiratory alkalosis prior to circulatory arrest. After termination of cooling the body temperature usually drifted down to between 18° and 20° C. Circulatory arrest time was approximately 50 minutes. About one minute before beginning artificial heart pumping, the animal was mechanically ventilated at about 4/min. After completion of the surgical procedure the animal was placed in a tub of water at 42° C in the kneeling position. Hyperventilation was employed during rewarming but correction of acid-base imbalance was generally not necessary. Rewarming was terminated at a rectal temperature between 35° and 37° C.

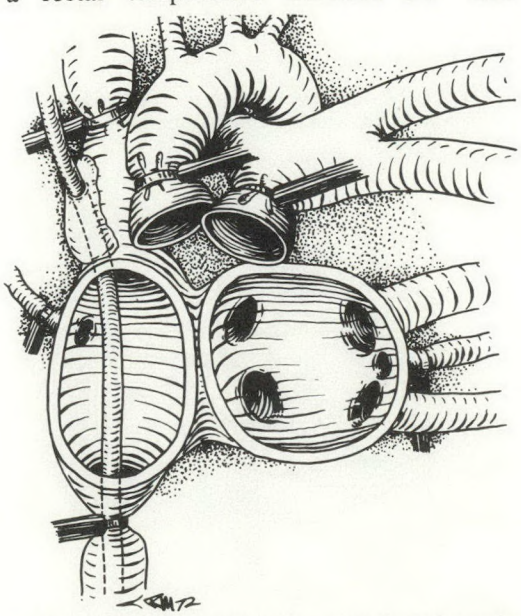

Fig. 4.—The ventricles are resected at the atrioventricular groove and the arteries are divided close to the ventricles.

Resection of the Natural Heart

After blood flow to and from the heart was interrupted by occluding the vessels with pieces of umbilical tape passed through Tygon tourniquets, the apex of the heart was grasped by a large Kocher's forceps. The left and right ventricles were incised at the apex, and the blood in both ventricles was aspirated. Most of the ventricular muscle was quickly excised. The pulmonary artery was divided near the pulmonary valve. The remaining ventricular muscle and fatty tissue was carefully excised along the atrioventricular groove. The aorta was then transected near the aortic valve, care being taken to separate gently the aorta from the right atrium (Fig. 4).

Insertion of the Artificial Heart

The atrial cuffs, which were separate from the ventricles, were inverted into the atria. The rims of the natural atria and the cuffs were then held together with four or five Allis forceps, and sutured in a continuous manner with 000 Mersilene (Fig. 5). After completion of the right and then the left anastomosis, four flaps attached to the free edge of each atrial cuff were grasped by forceps and pulled upwards, everting the cuffs into a normal position. The ventricles and the atria were connected by wiring the atrial cuffs over the ventricular valve supporters (Fig. 6). The artificial and natural aortas were connected by tying the vessels over a rigid aluminum connector (Fig. 7). The pulmonary artery connection was ac-

complished in a similar fashion. The driving lines were passed through stab incisions in the chest wall and attached to the driving system of the artificial heart.

Priming and Pumping with the Artificial Heart

After the anastomosis was complete, the lines to the atrial pressure transducers were used for priming the heart with ACD blood (Fig. 8). The air vents placed at the upper parts of each artificial ventricle were closed after the artificial heart was completely primed and all air evacuated. As soon as both ventricles were fully primed, the tourniquets around the veins were released and the aortic clamp was removed. Pumping of the artificial left ventricle was begun first with a rate of 30/min and a stroke volume of about 50 ml. The right atrial pressure was maintained above 0 mm Hg to avoid the aspiration of air through the anastomosis. The superior vena caval catheter was clamped and the pulmonary artery clamp was completely released. The pump pressure and frequency were gradually increased as cardiopulmonary bypass flow was reduced. Finally, the inferior vena caval catheter was clamped to increase the right atrial pressure. Residual fluid in the cardiopulmonary bypass circuit was gradually infused into the animal until an arterial mean pressure of 70 to 100 mm Hg could be maintained or the right and left atrial pressures remained above 0 mm Hg (Fig. 9). After the animal's condition was stabilized and further blood

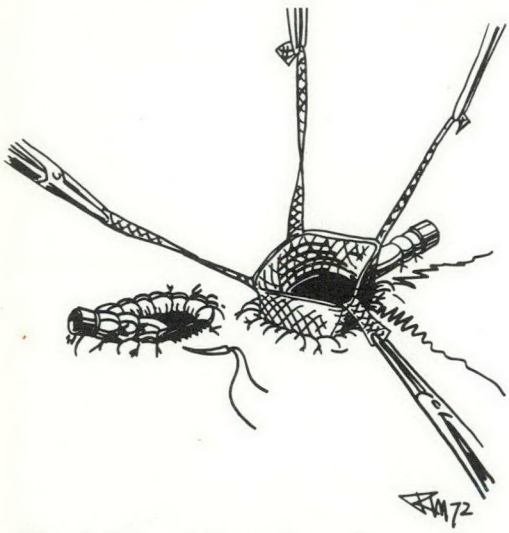

Fig. 5.—The atrial suturing cuffs are anastomosed to the natural atria in an inverted fashion, then pulled upwards to accept the artificial ventricles.

Fig. 7.—The natural arteries are pulled over the connectors and secured with umbilical tape.

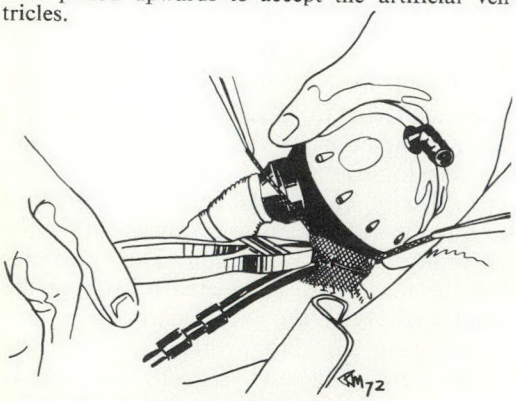

Fig. 6.—Each atrial cuff is wired over a ventricular valve holder.

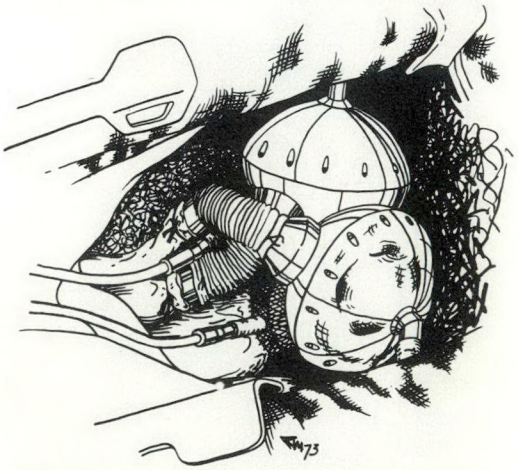

Fig. 8.—After the ventricles have been primed with blood via atrial pressure lines, pumping at a slow rate with a low driving pressure is initiated.

transfusion was not required, the venous and arterial lines of the cardiopulmonary bypass were removed.

Postoperative Treatment

Protamine sulfate was given intravenously in a dose of 6 mg/kg or until the whole-blood clotting time returned to between eight and 12 minutes. Chest tubes were inserted into both pleural spaces and connected to chest suction. The halves of the sternum were approximated with stainless-steel wire sutures and the chest wall was closed in two layers. The animal was transferred to a specially constructed mobile cage in the kneeling position (Fig. 10). Respiratory assistance was continued to maintain acceptable levels of arterial oxygen saturation. Intravenous fluids and blood were given to the animal as occasion demanded.

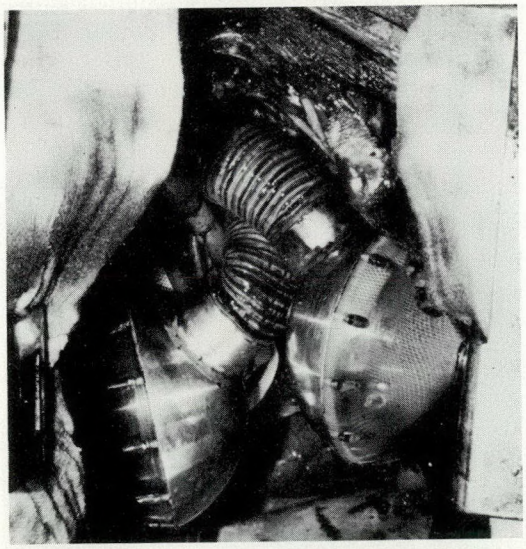

Fig. 9.—When a mean arterial pressure of 70 to 100 mm Hg is reached at about 90 beats per minute, all pressure lines are removed from the heart and the chest is closed.

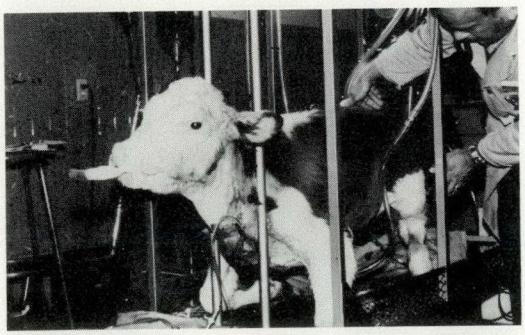

Fig. 10.—In this special cage the calf is restrained only by head bars and can stand up at will. This calf is breathing spontaneously during the second postoperative day.

Vital signs were carefully observed. Urine output, systemic arterial, pulmonary arterial, right atrial, left atrial and central venous pressures were continuously monitored. Arterial and venous blood gas, routine hematology and blood chemistry examinations were also monitored in the postoperative phase.

Comment

A few critical points of technique are: (1) careful resection of ventricular muscle along the atrioventricular groove; (2) resection of the pulmonary artery before division of the aorta; (3) careful transection of the aorta to avoid damaging the right atrium; (4) careful closure of the sternum to avoid dehiscence; (5) careful planning of the initiation of pumping. The left ventricle is started first with a small stroke volume and slow rate; once stabilization has occurred, the right ventricle is started and weaning from cardiopulmonary bypass is easily accomplished.

Summary

We have developed an uncomplicated surgical procedure for orthotopic total artificial heart transplantation in calves. Our procedure can utilize either cardiopulmonary bypass or deep hypothermia. Forty-three implantations by these methods have led to routine survival for up to 33 hours.

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GIANT CELL TUMOUR OF DISTAL RADIUS REPLACED BY MASSIVE FIBULAR AUTOGRAFT: A CASE REPORT

S. M. PARKER, M.D., D. E. HASTINGS, M.D., F.R.C.S.[C] and V. L. FORNASIER, M.D., *Toronto, Ont.*

Summary: The authors present a case of giant cell tumour of the distal radius replaced by massive fibular autograft. Recurrence rates for giant cell tumours treated by curettage and bone grafting are extremely high. Complete excision of the tumour is the procedure of choice.

Résumé: Les auteurs présentent un cas de tumeur à cellules géantes du radius distal qui a été remplacée par une homéogreffe péronière massive. On sait que les tumeurs à cellules géantes qui sont traitées par simple curetage ou par greffe osseuse sont sujettes à des récidives très fréquentes. Le traitement par excellence consiste à exciser complètement la tumeur.

Reprint requests to: Dr. D. E. Hastings, Orthopaedic Office, The Wellesley Hospital, 160 Wellesley Street East, Toronto, Ont. M4Y 1J3.

RECURRENCE rates of up to 70% for giant cell tumours of bone treated by curettage and bone grafting have been reported.[1] In 1965 Wilson and Lance,[2] in a series of 32 primary tumours of bone, reported 13 giant cell tumours of which four were situated in the distal radius. Three of these were treated with curettage and bone grafting and all recurred; in one the procedure was repeated before resorting to resection of the tumour and reconstruction with iliac bone graft and wrist fusion; two eventually required amputation for recurrence of the tumour. Complete excision of the tumour offers the best chance for cure but presents significant reconstructive problems.

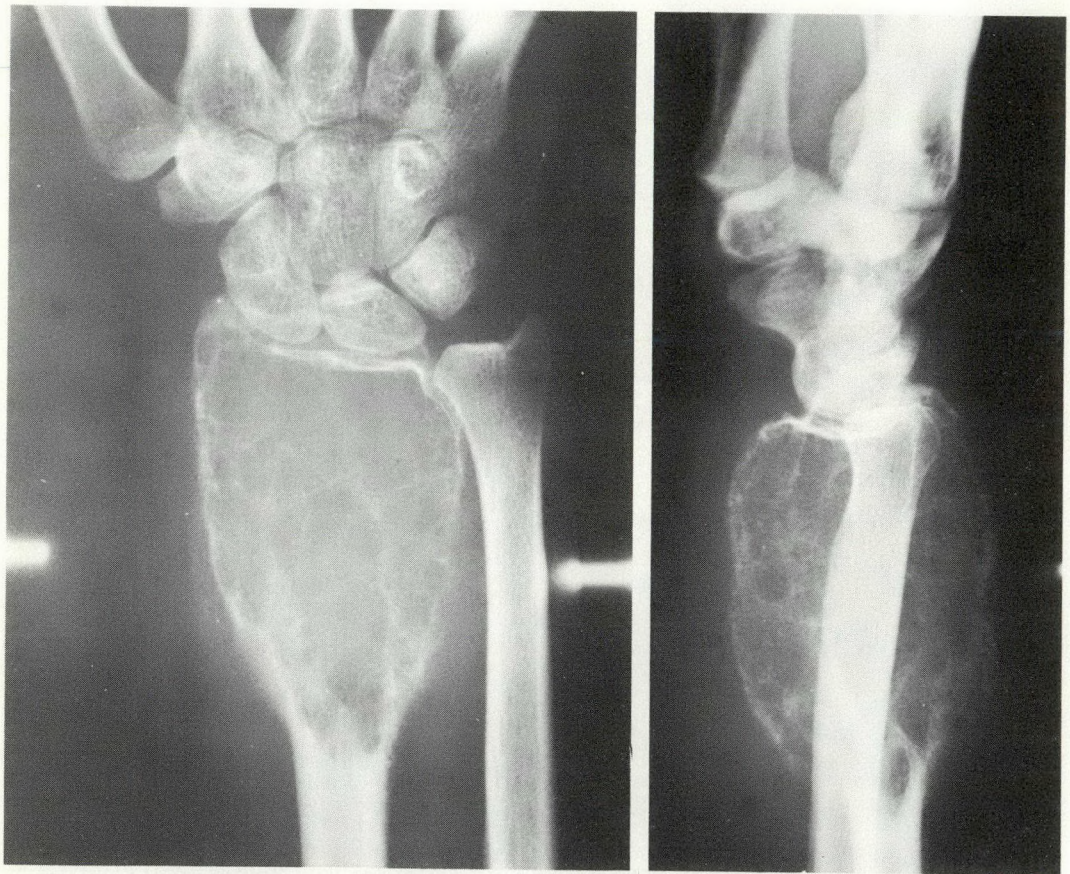

Fig. 1.—(a) Anteroposterior and (b) lateral radiographs of the left distal radius showing an expansile lesion with a trabecular pattern extending up to the articular surface of the radius.

Case Report

A 19-year-old housewife was admitted to the Wellesley Hospital, Toronto, in August 1971 with an 18-month history of left wrist pain aggravated by motion and a rapidly enlarging mass of four months' duration.

She appeared a healthy young woman, who was four months pregnant. At the left wrist there was a firm, tender, fusiform swelling of the distal radius. Movement of the wrist was as follows: dorsiflexion 15°, volar flexion 35°, pronation 30° and supination 80°.

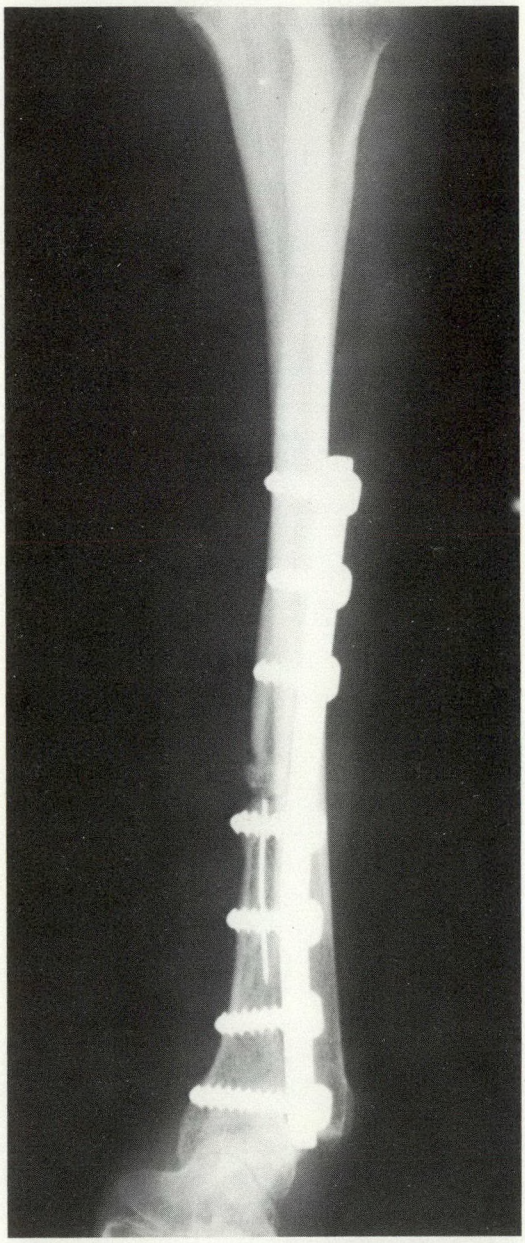

Fig. 2.—Lateral radiograph of the left forearm 18 months after operation showing replacement of the distal radius by fibular autograft.

Laboratory investigation and chest radiographs were normal. Radiographs of her left wrist (Fig. 1) showed an expanding lesion with a thin trabecular pattern in the distal radius, which crossed the epiphysis and extended to the articular surface of the radius. This appearance was characteristic of a giant cell tumour.

The distal radius was excised *en bloc* without previous biopsy. This was done through a midline dorsal incision, reflecting the extensor retinaculum and its tendons in an ulnar direction. A separate incision was made in the sheath of extensor pollicis brevis and abductor pollicis longus. The inferior radioulnar joint was divided and the distal 8 cm of the radius excised with a 1½-cm length of healthy bone proximally.

Ten centimetres of the proximal left fibula was removed. The fibular autograft was cut to the same length as the excised radius. However, it was necessary to add another 6 mm in length to obtain appropriate tension on the carpus. The graft was secured to the distal radius with a seven-hole AO plate. The distal end of the ulna was stabilized by suturing the extensor retinaculum to the periosteum on the dorsal aspect of the fibula and dorsal aspect of the carpus. This also covered the plate. The overall stability following the soft tissue repair appeared satisfactory.

After the operation a long-arm plaster was applied for six weeks and a forearm plaster for a further six. At three months the patient was fitted with a moulded forearm support to protect her graft. Radiographs of her forearm at 18 months (Fig. 2) suggested that union between the fibula and proximal radius had begun. Eighteen months after reconstruction she had 10° of dorsiflexion, 20° of palmar flexion, nearly full pronation and 20° of supination. She was free of pain.

Discussion

Starr,[3] in 1945, was the first to describe the fibular autograft. This was for the treatment of congenital absence of the radius and he refers to earlier cases where it had been used as replacement for distal radius resected because of tumour. In 1952 Lawson[4] described a case of fibular transplant for osteoclastoma of the radius. Parrish,[5] in 1966, reported two cases of fibular transplant to replace resected distal radius

and advised that the head of the fibula be fashioned in a semilunar shape to avoid carpal dislocation. No such modification was made to the fibula in our case and no carpal dislocation has occurred.

Segments of long bones in large measure die after transplantation, with only the most superficial parts surviving to be a source of osteogenesis. Long-bone grafts are revascularized from the periosteal surface and by vessels growing into the medullary canal from the ends.[6]

Tuli,[7] in 1972, noted that successive radiographs taken during follow-up of massive autologous bone grafts revealed the processes of resorption and reconstruction occurring simultaneously. Reconstruction seemed to spread from the host-graft junction towards the centre of the graft. Radiological evidence of complete reconstruction occurred seven to 18 months after operation. He noted that fracture of the graft may take place when reconstruction lags behind resorption and therefore advised prolonged splinting of the limb. Our patient continued in her protective forearm splint for 18 months.

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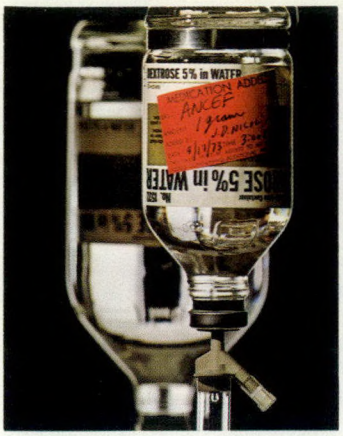

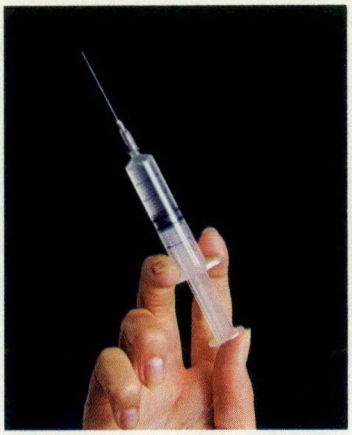

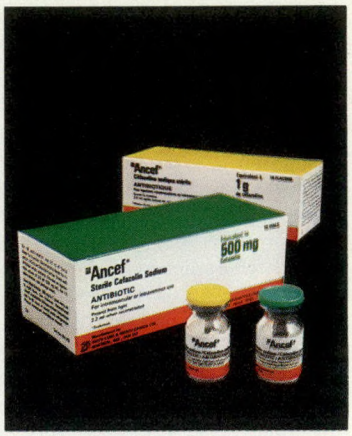

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ILEAL CONDUIT DIVERSION FOR BENIGN DISEASE: A CRITICAL REVIEW AND LONG-TERM FOLLOW-UP*

J. K. WYATT, M.D., F.R.C.S.[C], F.A.C.S.,† *London, Ont.*

Summary: The ileal conduit has been criticized for having a high complication rate and doubt expressed as to its long-term effectiveness as a means of urinary diversion. The author has critically reviewed 73 cases of ileal conduit performed for benign disease and has demonstrated that there is a rate of 21% for early and of 39% for late complications. Twenty-one cases of the series had a follow-up of 10 to 15 years. Their analysis demonstrated that the major complications and loss of renal function occur in the first few years after operation and, furthermore, that the ileal conduit is a satisfactory means of preserving renal function for a long period of time.

Résumé: On a accusé le processus consistant à utiliser le conduit iléal comme moyen de détournement urinaire d'entraîner de nombreuses complications et on a formulé des doutes sérieux quant à son efficacité à long terme. L'auteur a passé au crible de la critique 73 cas de conduit iléal pratiqué pour des pathologies bénignes et a fait remarquer que cette opération entraîne des complications précoces dans 21% des cas et des complications tardives chez 39% des malades. Dans 21 cas de cette série, les malades ont été suivis pendant des périodes variant de 10 à 15 ans. Cette analyse a permis de mettre en évidence que les principales complications et la perte de la fonction rénale surviennent dans les quelques années qui suivent l'opération et, par ailleurs, que le conduit iléal est un moyen de conserver la fonction rénale pendant une longue période.

ALTHOUGH the ileal conduit appears to provide one of the most satisfactory means of urinary diversion, not only is its formation an operation of considerable magnitude but two major criticisms are, first, that the complication rate is too high;[1-5] and, second, that the long-term results are untested.[6, 7] These criticisms led the author to carry out a critical review of the procedure with particular emphasis on the long-term aspects of the ileal conduit as a means of diversion for benign disease.

CASE MATERIAL AND RESULTS

A review was made of 241 ileal conduits performed on the Urological Service of the Victoria Hospital, London, Ontario from 1957 to 1970. Of these, 66% (159 cases) were performed for carcinoma of the bladder or other forms of pelvic carcinoma (Table I). It is obvious that in this group of patients many additional variables, such as the carcinoma itself and radiotherapy, made a true assessment of the diversionary procedure difficult. It was believed that a more critical assessment of the ileal conduit would be best obtained by studying the cases of patients who had had their ileal conduit performed for non-malignant disease (Table II). Seventy-three such cases were critically reviewed with 100% follow-up. There were 43 females and 30 males. The age range was from 2 to 77 years; 23 were children and 10 patients were over the age of 65 years.

As mentioned, one of the major reasons for the study was what appeared to be a high complication rate. There were early complications during the initial hospital stay in 21% of cases (Table III). The commonest of these was wound dehiscence. In all five cases in which this occurred the closure used was a running, chromic, catgut suture with reinforcing anterior fascial sutures of catgut. In only one of the five cases did there

TABLE I.—ILEAL CONDUITS PERFORMED FOR CARCINOMA

Neoplasm	*No. of cases*	*Percentage*
Bladder	113	47
Cervix	19	8
Prostate	9	4
Bladder and prostate	5	2
Other pelvic neoplasms	13	5
Total	159	66

*Presented at the Canadian Urological Association Meeting, Vancouver, B.C., June 1973.

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appear to be any undue tension at the suture line and this was in a 4-year-old girl with extrophy of the bladder. There has been no case of dehiscence in the last four years covered by the study, during which an interrupted, through-and-through closure of nonabsorbable suture, preferably Dacron, has been used.

In an analysis of the problems related to ureteroileal anastomosis no common factor could be found except that all four of the complications occurred on the left side. Great care must be taken to minimize the dissection of the left ureter. In addition, one should bring the ureter through a window in the mesosigmoid rather than beneath the mesosigmoid in an attempt to prevent its involvement in an area of retroperitoneal fibrosis.

Both patients with septicemia in the early postoperative period had a significant degree of urinary tract obstruction and pyelonephritis before the ileal conduit operation. In retrospect, perhaps a more vigorous attempt at preoperative control of the infection might have averted the septicemia. The author employs both mechanical and antibacterial bowel preparation. In the two instances of small bowel fistula, one developed at the original suture line and required a small bowel resection and reanastomosis. In the second case drainage occurred into the ileal conduit and in some unusual manner ceased spontaneously. The two cases of mechanical small bowel obstruction were at five and 13 days after operation. One patient required the release of a loop of bowel and in the other the obstruction was associated with a local leak at the anastomosis and the patient required a small bowel resection. There were three deaths, two from septicemia and one from staphylococcal pneumonia, which gave an operative mortality rate of 4%.

Late complications of ileal conduit diversion, that is, those occurring any time after the initial hospital discharge, were more frequent than the early. Twenty-seven of 70 patients developed these complications, an incidence of 39% (Table IV).

The most common complication in the late period was ureteroileal obstruction; there were eight such cases, seven of which required a revision of the anastomosis and in one patient a nephroureterectomy was done. These problems were equally divided between the right and left ureteroileal anastomoses. The time lapse from operation was from three months to seven years. In the seven cases of anastomotic revision, the etiological factor appeared to be devitalization and scarring of the ureterointestinal anastomosis. All of these anastomoses had been done by a similar technique with a two-suture, running type anastomosis using fine chromic catgut, usually 4-0.

The second commonest late complication was obstruction at some level of the conduit. Six cases fell into this category and three of them were stomal stenoses, which required

TABLE II.—ILEAL CONDUITS PERFORMED FOR NON-MALIGNANT DISEASE

Indication		*No. of cases*
Neurogenic bladder:		35
Myelomeningocele	20	
Spinal cord trauma	7	
Multiple sclerosis	5	
Poliomyelitis	1	
Arachnoiditis	1	
Encephalitis	1	
Congenital anomalies:		22
Megacystitis-megaloureters	16	
Extrophy	4	
Fistulas	2	
Cystitis:		11
Intractable	6	
Interstitial	3	
Irradiation	1	
Tuberculous	1	
Perineal fistulas:		5
Urethral stricture	3	
Rectovaginal	1	
Rectovaginovesical	1	

TABLE III.—EARLY COMPLICATIONS (73 CASES)

Complication	*No. of cases*
Wound dehiscence	5
Ureteroileal disruption	4
Septicemia	2
Fistulas	2
Small bowel obstruction	2
Operative death	3

TABLE IV.—LATE COMPLICATIONS (70 CASES)

Complication	*No. of cases*
Ureteroileal obstruction	8
Conduit obstruction	6
Renal calculi	6
Small bowel obstruction	5
Hyperchloremic acidosis	2

minor revision. One patient, a young girl, had her stoma revised on three separate occasions, two, three and seven years after the original conduit operation. The obstruction in one patient was at the level of the fascia, in one it was in the loop itself, and one obstruction was produced by prolapsing of other small loops around the ileal stoma. The author has made no attempt to formulate a program of stoma dilatation. Perhaps this should be given some thought, particularly in the conduits done in children, as the three cases in this series all occurred in children. Once the stenosis has begun, it is very difficult to get either the child or the parent forcibly to dilate the stoma.

Renal calculi were found as late complications in six patients of the 70 reviewed, an incidence of almost 9%, which compares favourably with the results in most long-term follow-up studies.[8, 9] Two patients had bilateral renal calculi; in two the calculi were left-sided and in two they were in the right kidney. Two patients were not submitted to operation but are being followed up while on a conservative regimen. In one of the four patients operated upon, one kidney was almost totally non-functioning and was removed; in the other three patients a straightforward pyelolithotomy was performed.

Small bowel obstruction occurred in five cases. In two of these the obstruction involved the ileal conduit as well, and construction of a second conduit was necessary. In one instance small bowel resection was required and the other two patients were relieved without a resection.

Only two patients developed problems connected with hyperchloremic acidosis. In both rather long loops had been inserted initially and these required revision.

In most cases sufficient data have not been recorded to permit accurate comparison of preoperative and postoperative renal function. If we use the excretory pyelogram as a crude measure, 24 of the 73 patients had normal intravenous pyelograms preoperatively, and these remained so postoperatively (Table V). Twenty of the patients had marked bilateral hydronephrosis before operation; half of these remained unchanged, eight improved, and only two really showed any increase in the amount of hydronephrosis after operation. Fifteen patients had unilateral hydronephrosis and of these, four remained unchanged and four improved. Seven of the 15 deteriorated but this figure is weighted because in many of them the deterioration was due to obstruction of the anastomosis, already considered as a complication under that heading and subsequently operated upon and revised. Eleven of this group of 73 had bilateral chronic pyelonephritic changes on the intravenous pyelograms; seven of these remained unchanged, two improved and two deteriorated. Three kidneys were lost in the entire group of 73 patients.

Discussion

The chief aim of ileal conduit diversion is to preserve renal function. This study emphasizes that if the upper urinary tracts are normal, this aim can be achieved. Twenty-four of our 73 cases were in this category and in all of these renal function remains normal. Even of the 31 cases that had either massive bilateral hydronephrosis or chronic pyelonephritis before operation 10 showed marked improvement whereas only four deteriorated after the diversion. In the other

TABLE V.—Preoperative and Postoperative Comparison of Excretory Pyelography

Preoperative		*Postoperative*	
Normal	24	Normal	24
Bilateral hydronephrosis	20	Unchanged	10
		Improved	8
		Deteriorated	2
Unilateral hydronephrosis	15	Unchanged	4
		Improved	4
		Deteriorated	7
Chronic pyelonephritis	11	Unchanged	7
		Improved	2
		Deteriorated	2

17 cases the excretory pyelogram remained unchanged after the diversion.

In addition to the general follow-up of these patients, the author had the opportunity in 21 patients to carry out a long-term follow-up of 10 to 15 years' duration. It was possible to determine the blood urea nitrogen levels in 11 of these 21 patients and in 10 of the 11 the levels have remained normal. One 8-year-old boy had a preoperative value of 35 mg/100 ml. Now, at the age of 20 years, this has risen to 76 mg/100 ml and he is currently on the chronic renal dialysis program at our hospital. Only two patients, both with gross upper tract destruction when first seen, have had problems with hyperchloremic acidosis following the establishment of conduit drainage. Both received total ureteral replacement which required relatively long loops. One patient, 14 years later and after a loop revision, has shown marked clinical improvement and is easily controlled with 30 g of sodium bicarbonate daily. The other patient is the 20-year-old man referred to above.

Sixteen of these 21 patients had follow-up excretory pyelograms to allow comparison with their preoperative status (Table VI). Of these, nine have improved or remained normal. In one instance the degree of hydronephrosis has remained unchanged. Six of the patients showed an increase in the degree of hydronephrosis postoperatively, over the 10- to 15-year period; in three of them the hydronephrosis was unilateral and mild, and has remained unchanged in the long-term period. In the other three cases the kidneys have been lost as the result of ureteroileal obstruction and severe pyelonephritic changes within 10 years of the conduit operation.

TABLE VI.—LONG-TERM FOLLOW-UP (21 CASES)

	No. of cases	
Blood urea nitrogen:		11
Normal	10	
Increased	1	
Hyperchloremic acidosis		2
Excretory pyelogram:		16
Normal or improved	9	
Unchanged	1	
Increased hydronephrosis	6	

This long-term study emphasizes that the major complications and loss of renal function occur in the early years after conduit diversion. When 10 years and up to 15 years have elapsed there does not appear to be any increase in the complication rate or further loss of renal function.

The author wishes to acknowledge the assistance of Mr. George Dundas, a final-year medical student, who carried out the chart review. The author is also indebted to Drs. L. N. McAninch and J. L. Sales for allowing him to review their patients.

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MUCOSAL DIAPHRAGM OF THE GASTRIC ANTRUM: CASE REPORT AND REVIEW OF THE LITERATURE*

C. N. GHENT, M.D.† and D. DENTON, M.D., *London, Ont.*

Summary: A 52-year-old woman had a mucosal diaphragm obstructing the gastric antrum. This rare but important and treatable cause of gastric obstruction usually presents as pyloric stenosis without a history of ulcer dyspepsia. Diagnosis is possible by distinctive radiological features, but is often made only by endoscopy and/or surgical exploration. Surgical treatment has been highly satisfactory in most cases described in the literature. Our case is unique in that the anomaly was associated with a gastric phytobezoar and with prolonged postoperative gastric aperistalsis.

Résumé: Une femme de 52 ans souffrait d'un diaphragme muqueux, qui obstruait l'antre gastrique. Cette pathologie curable, cause de l'obstruction gastrique s'observe rarement, mais est importante. Elle se présente fréquemment sous forme d'une sténose pylorique, sans antécédent de dyspepsie ulcéreuse. On peut poser le diagnostic par des méthodes radiologiques distinctives, mais on fait souvent ce diagnostic par simple endoscopie et par une exploration chirurgicale (ou l'une des deux méthodes). Dans la plupart des cas rapportés dans la littérature, le traitement chirurgical s'est révélé très satisfaitsant. Notre cas est unique, en ce sens que cette anomalie était associée à un phytobézoard gastrique et à une absence prolongée de peristaltisme gastrique, d'origine postopératoire.

A MUCOSAL diaphragm obstructing the antrum of the stomach is a rare abnormality, generally considered to be congenital. There is some disparity in the numbers of reported cases,[1, 2] due, in part, to confusion over the nomenclature and classification of antral or pyloric lesions not obviously related to inflammatory, neoplastic or peptic ulcer disease. The case we report below represents the type of lesion best described as an antral mucosal web, diaphragm, or membrane, and is unique in that it was associated with a large intragastric phytobezoar, and with prolonged postoperative gastric aperistalsis.

CASE REPORT

A 52-year-old housewife had a 10-year history of intermittent, increasing, abdominal distension, belching and vomiting after meals. These symptoms were better during the winter and worse during the summer. She related the seasonal exacerbations to the ingestion of fresh raw fruits and vegetables, especially salads and peas.

On physical examination the patient appeared as a healthy-looking woman with no notable abnormalities apart from epigastric distension and a succussion splash. Results of routine laboratory tests were normal. Upper gastrointestinal radiographs (Fig. 1) showed a constant concentric narrowing of the distal antrum and a large bezoar in the fundus. The bezoar was cleared by voluminous, forceful tapwater lavage with returns of thick, greenish debris, containing vegetable fibre and peas.

At gastroscopy the mucosa appeared normal. A circular aperture, constant in size, was present in the distal antrum and beyond it was a small vestibule, lined by normal gastric mucosa terminating at a normal pyloric sphincter. The aperture appeared to be centrally placed in a mucosal web across the antrum. By grasping its edge with biopsy forceps, the membrane was shown to be mobile while the size of the opening remained unchanged. A biopsy from this edge showed normal gastric mucosa.

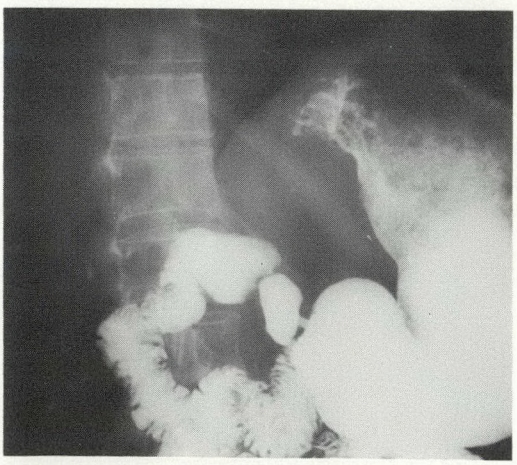

Fig. 1.—Note the constant concentric narrowing in the distal antrum and the phytobezoar in the fundus of the stomach.

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At laparotomy the serosal surface of the stomach and duodenum was normal, and there was a suggestion of an hour-glass deformity 2 to 3 cm proximal to the pylorus. A "doughnut deformity" was palpable in the antrum separate from the pylorus. Through a proximal gastrotomy incision it was seen to be covered by normal gastric mucosa and there was no evidence of ulceration or neoplasm. The membrane was incised longitudinally, closed transversely and a small Heineke-Mikulicz pyloroplasty was performed. Postoperative progress was uninterrupted and the patient was discharged seven days later.

Ten days after discharge she returned with complaints of postprandial nausea, vomiting and epigastric fullness. On examination there was obvious gastric dilation with a succussion splash. Barium examination revealed a widely patent pylorus, but no antral peristalsis and slow gastric emptying. Endoscopy two weeks later showed no evidence of the diaphragm and a normal pyloric sphincter, but again antral peristalsis was absent, even after administration of metoclopramide. Six weeks later she was tolerating a regular diet, had no symptoms and was gaining weight.

Discussion

Congenital anomalies of the stomach are rare, accounting for less than 1% of all congenital gastrointestinal disease.[1] Gerber[2] classified congenital obstructive anomalies, other than infantile hypertrophic pyloric stenosis, into four categories, namely pyloric membranes, antral membranes, pyloric atresia and antral atresia. The age range is from the neonatal period to 74 years[3, 4] and there is no good reason for considering infant and adult cases separately. Sloop and Montague[5] reviewed the reports to 1967 and found 16 cases of a membrane occurring at the pyloric sphincter, 21 in the antrum and three in which the exact location was not specified. In 1970 McBee and North[6] reported 47 patients, but did not differentiate them on the basis of site. Since then there have been four additional case reports of antral membranes[7-9] including our patient.

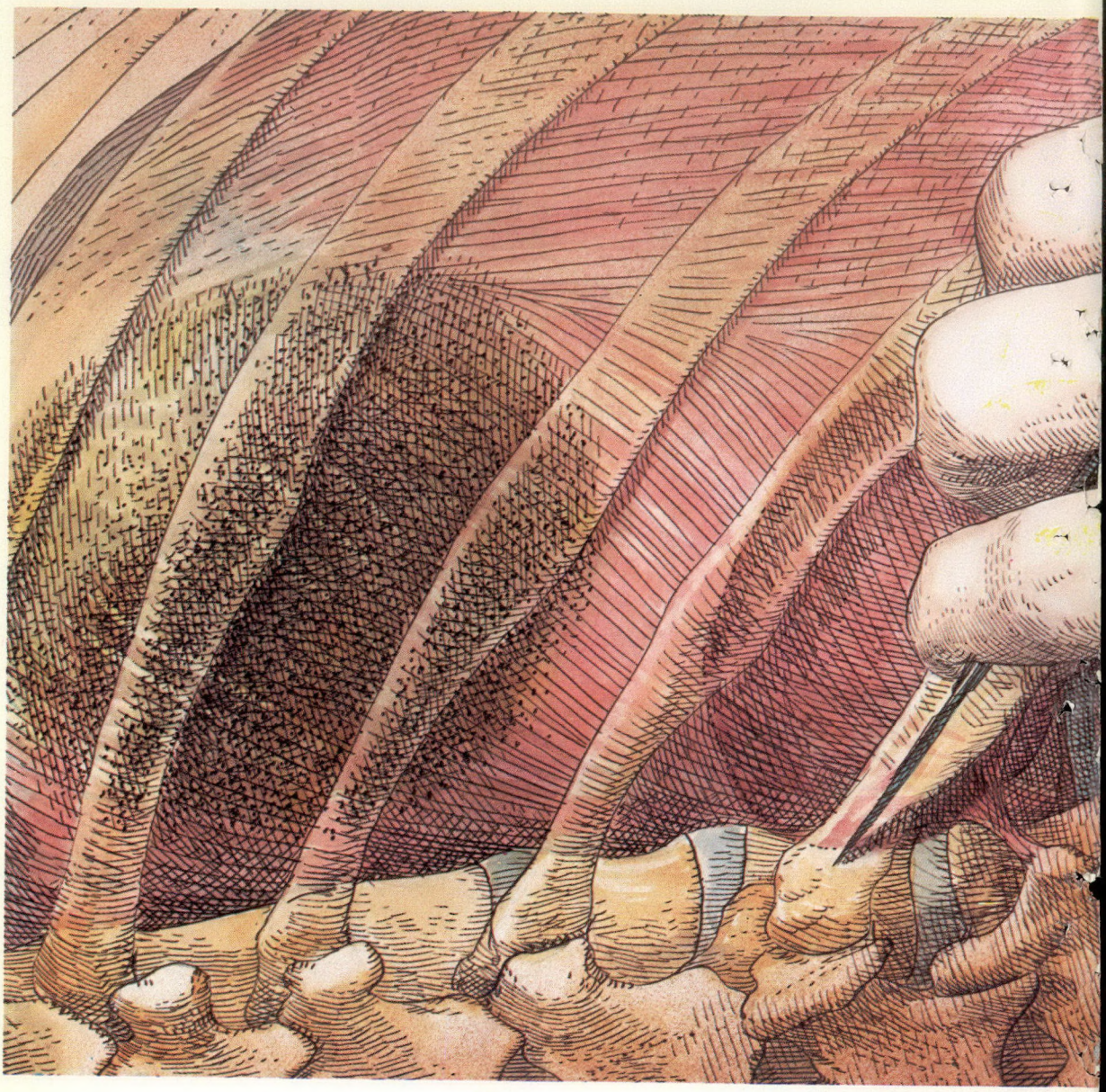
From all available reviews and case reports, and using Gerber's classification, one arrives at the total number reported in each class as follows: antral mucosal membrane, 36; antral atresia, 11; pyloric mucosal membrane, 27; and pyloric atresia, six. There are another seven cases in which the data do not permit classification. At least one case seemed to be a combination of partial antral atresia and antral mucosal membrane.[7] These anomalies may not be as rare as the above figures suggest. For example, Rhind[10] reported seven from personal experience, and Kenny[11] and Strange[12] reported four each.

Most authors consider the antral diaphragm to be due to a failure of canalization of the solid cord of gut epithelium at five to six weeks of fetal development. The rarity of these lesions in the stomach (compared with the duodenum) and the fact that all membranes have at least a small aperture, may be related to the observation that during embryogenesis luminal occlusion in the stomach is never complete.[13] There are other indicators of a congenital etiology. For example, one antral membrane consisted of ectopic pancreatic tissue.[9] The age range of the reported cases, including infancy, the absence of significant evidence of inflammation in most cases and the embryological considerations all support the concept of a congenital etiology.

The clinical features in our patient are typical. Painless bloating and vomiting have been the main symptoms and their duration before diagnosis has ranged from two months to 23 years. The first case, reported by Landerer[14] in 1897, was an incidental autopsy finding, and there has been one recent report of an asymptomatic antral diaphragm.[15] Muscular hypertrophy overcoming the partial obstruction may have been responsible for this patient's prolonged asymptomatic period; it is conceivable that removal of the bezoar alone would have eliminated her symptoms indefinitely.

The diagnosis has been made and missed by a variety of means.[8] Although the constant ring-like constriction has been present and observed on radiographs it has usually been misinterpreted. Gastroscopic examination has provided the correct diagnosis in at least five cases, including ours. In the majority the diagnosis has been made at laparotomy or when the organ was examined after gastrectomy.

In most cases treatment has been surgical and the results generally have been good. Initially gastroenterostomy was usually done but recently incision of the membrane com-



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Tracy, O., et al. (29 Jan.'72).
Brit. med. J., p. 280.

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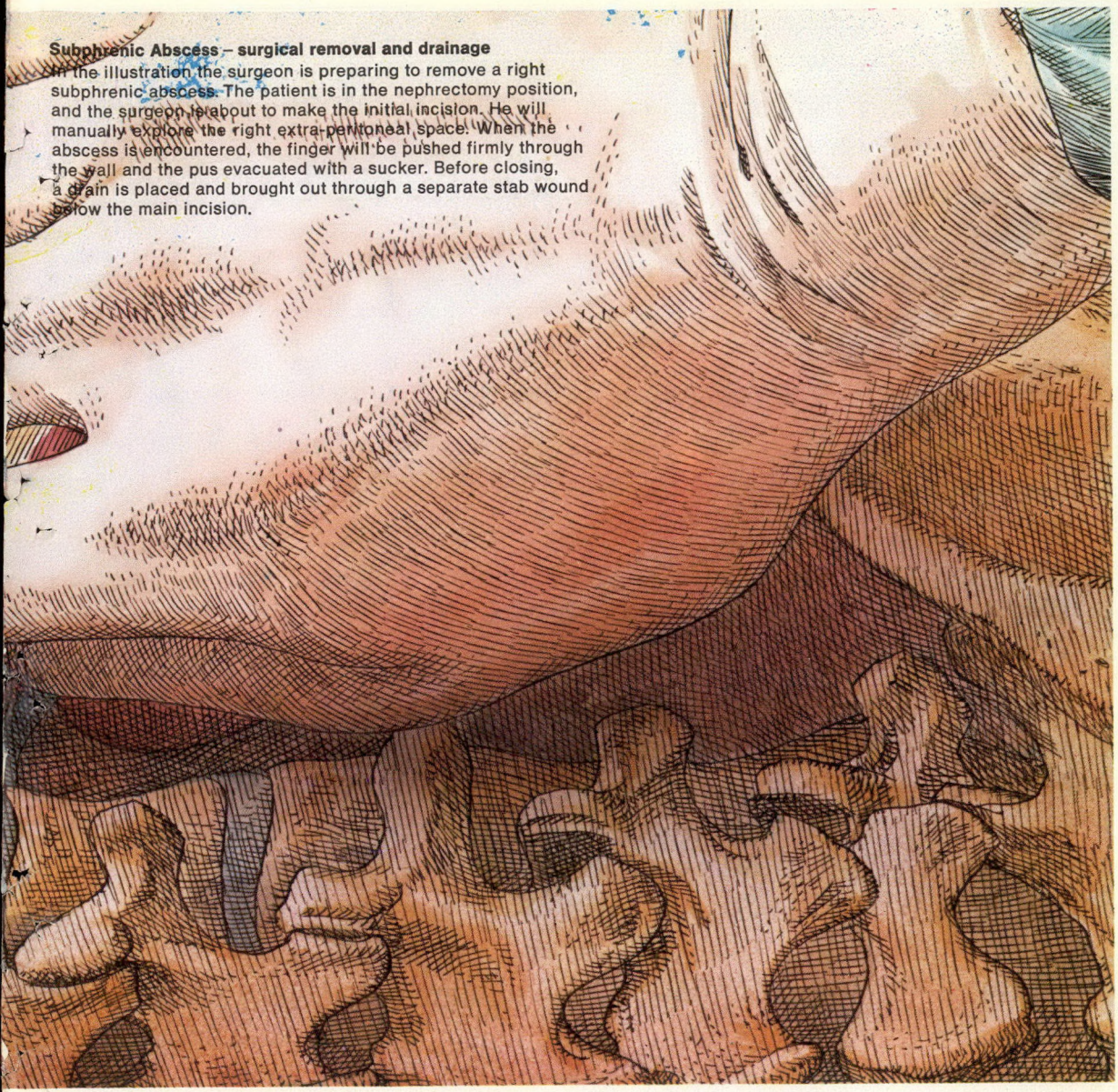
Haldane, E.V. and van Rooyen, C.E. (1972).
C.M.A.J., p. 1177.



Subphrenic Abscess – surgical removal and drainage
In the illustration the surgeon is preparing to remove a right subphrenic abscess. The patient is in the nephrectomy position, and the surgeon is about to make the initial incision. He will manually explore the right extra-peritoneal space. When the abscess is encountered, the finger will be pushed firmly through the wall and the pus evacuated with a sucker. Before closing, a drain is placed and brought out through a separate stab wound below the main incision.

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bined with pyloroplasty has been advocated.[2] Katz[15] has considered the possibility of dilating the aperture by a peroral technique. The postoperative problem of prolonged gastric stasis with aperistalsis, as encountered in our case, has not previously been reported nor has the association with a phytobezoar.

Although rare, pyloric or antral membranes or areas of atresia should be considered in the differential diagnosis of upper gastrointestinal obstructive symptoms in patients of any age, especially episodic gastric outlet obstruction without any history of ulcer dyspepsia.

We wish to express our gratitude to Drs. W. C. Watson and J. Duff for allowing us to publish the details of this case, and for assistance in preparing the manuscript.

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LYMPHOGRAPHY IN CASES OF EDEMA OF THE LOWER EXTREMITY

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Summary: Bilateral lymphography was performed on 75 patients presenting with edema of the lower extremity. In 16 patients the lymphedema was classified as primary in type and in most of the 43 with secondary edema it was due to a malignant process. The remaining patients had a normal lymphogram and a normal venogram. The technique of the examination is briefly described and the results are evaluated. Radiographs of various types of lymphedema are presented.

Résumé: Nous avons pratiqué une lymphographie bilatérale chez 75 malades qui présentaient un œdème des membres inférieurs. Chez 16 de ces malades, le lymphœdème était considéré comme primaire et, chez la majorité des 43 malades avec oedème secondaire, il était causé par un processus malin. Les autres avaient un lymphogramme et un phlébogramme normaux. Nous décrivons brièvement la technique de l'examen et évaluons les résultats. Nous présentons également des radiographies de divers types de lymphœdème.

LYMPHEDEMA is the collection of lymph in the interstitial tissue resulting from a functional overload on the lymphatic system.[1] The physiopathology is not yet fully understood but the advent of lymphography has allowed better comprehension of this pathological process and has made possible differentiation between primary and secondary lymphedema. These two types of edema are discussed briefly below.

MATERIALS AND METHOD

From a series of some 1,000 lymphograms performed at the Royal Victoria Hospital in Montreal, we reviewed the records of 75 which were carried out as part of the investigation of edema of the lower extremity.

The method used was basically that of Kinmonth[2] with a few modifications. Usually the first web space was injected with Alphazurine 2G but whenever marked edema of the foot was present the blue dye was introduced also into the third web space to utilize a wider supply of draining lymphatics. In all cases the procedure was performed bilaterally through a longitudinal incision on the dorsum of the foot. No significant delay in wound healing or local infection was observed. A strip of strong silk adhesive tape was applied to bring the edges of the incision together; no sutures were used except in two cases where the edema was so marked as to prevent adequate approximation of the edges.

Lipiodol, 3 to 5 ml, was injected over a period of 30 to 50 minutes by means of a Hobbs injector. It appears important to keep the amount of the radiopaque medium as small as possible in order to minimize the risk of lymphangitis from stagnation in an impaired lymphatic system and also to decrease the risk of pulmonary embolism; a disturbed lymphatic circulation may result in the opening of lymphovenous communications which would permit delivery of a large bolus of oil to the lungs. Some authors even recommend the use of a water soluble contrast medium to prevent this complication.

RESULTS

Of the 75 patients included in this study, 16 were classified as having primary lymphedema since they showed no evidence of anatomic obstruction but had some maldevelopment of the lymphatic system (Figs. 1 to 3). Eleven patients demonstrated channels either fewer in number or smaller in size than normal, or whose fragility was increased. Two patients presented hyperplastic channels and three others were considered to have aplasia of lymphatics as no channels whatever could be found for cannulation. These last three all showed dermal staining after injection of the blue dye, indicating lack of patency of the usual major lymphatic routes. Fifteen of this group of 16 patients were women and over two-thirds were under 35 years of age.

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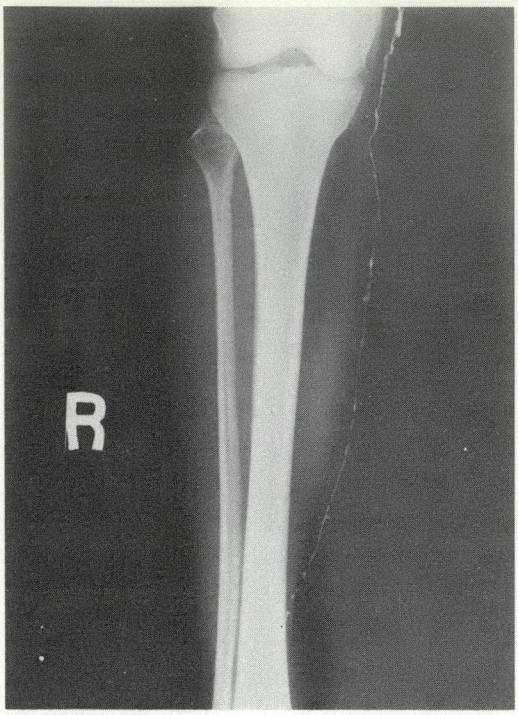

Fig. 1.—Primary lymphedema. A single hypoplastic channel parallels the greater saphenous vein. The lymphatic shows weakness of its wall and extravasation.

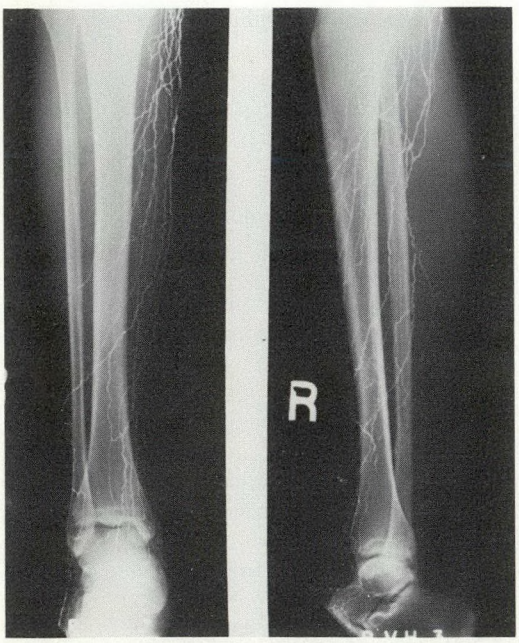

Fig. 2.—Primary lymphedema. Hyperplastic, multiple, tortuous channels are opacified in the leg of this 20-year-old woman in whom edema had been present for three months.

In a second group of 43 patients (23 women, 20 men), obstruction of the lymphatic system was demonstrated (Figs. 4 to 7). A malignant process was the cause of the obstruction in 31 patients, 19 of whom had edema caused by carcinomatous nodes in the pelvis which interrupted the flow of lymph and/or compressed the iliac veins. Twelve patients had nodes involved by Hodgkin's disease or other types of lymphomas.

A surgical operation in the groin was found to be the cause of the edema in six instances and lymphangitis in another six. It is quite possible that inflammation played a part in the edema resulting from an operation.

In a third group of 16 patients with edema

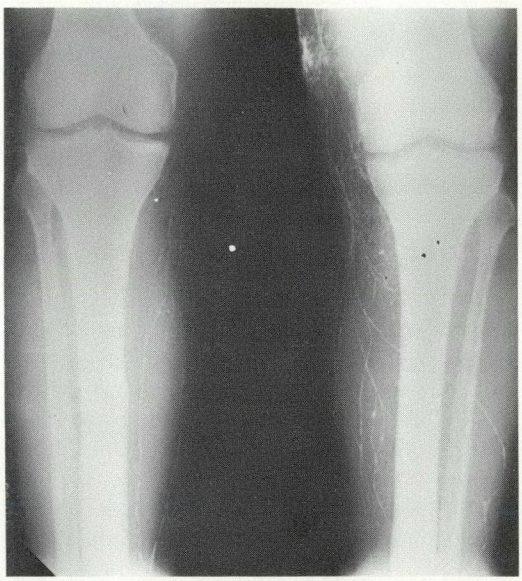

Fig. 3.—Primary lymphedema. Reflux of medium into distal collateral lymphatics after injection of a channel on the dorsum of the foot.

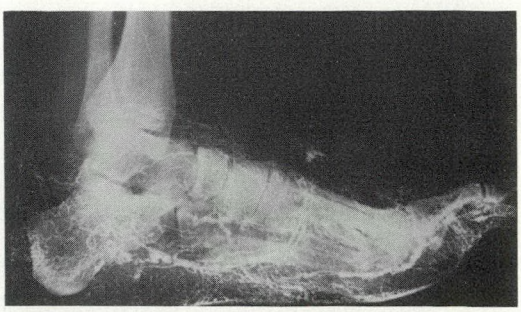

Fig. 4.—Secondary lymphedema. Opacification of collateral lymphatics and dermal backflow in a 53-year-old man who developed edema after resection of left inguinal nodes.

of the lower extremity suspected on clinical grounds to have a lymphatic basis, not a single abnormality could be found in either the lymphogram or the venogram. The edema is probably due to a defect at the cellular level. In these cases, lymphography was most valuable in ruling out obstruction.

Only two of our patients underwent operation for their lymphedema. Both had omental transposition and were objectively improved but lymphography failed to demonstrate any lymphatic connections with the greater omentum.

Discussion

Primary lymphedema is a congenital deficiency of the lymphatic system which manifests itself as hypoplasia, hyperplasia or aplasia of the lymphatic trunks. It predominantly affects women and is usually first noticed a short time after puberty.

Hypoplasia, i.e. vessels fewer in number and/or smaller in size than normal, is the most common lymphographic finding in primary lymphedema (approximately 60% of cases).[3, 4] In 25% of the patients the abnormality is bilateral. The diagnosis of hypoplasia is a relatively delicate one to put forward on the basis of a static record which does not reflect circumstances that are entirely physiological. The interpretation of such a record must obviously be made with caution.

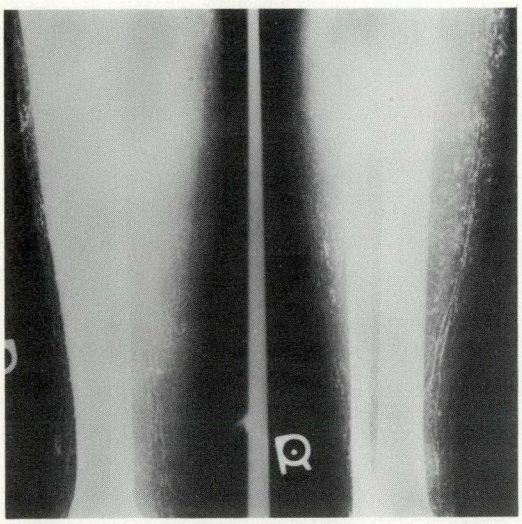

Fig. 5.—Secondary lymphedema. Extensive dermal collateral lymphatics in a patient who has had repeated episodes of lymphangitis.

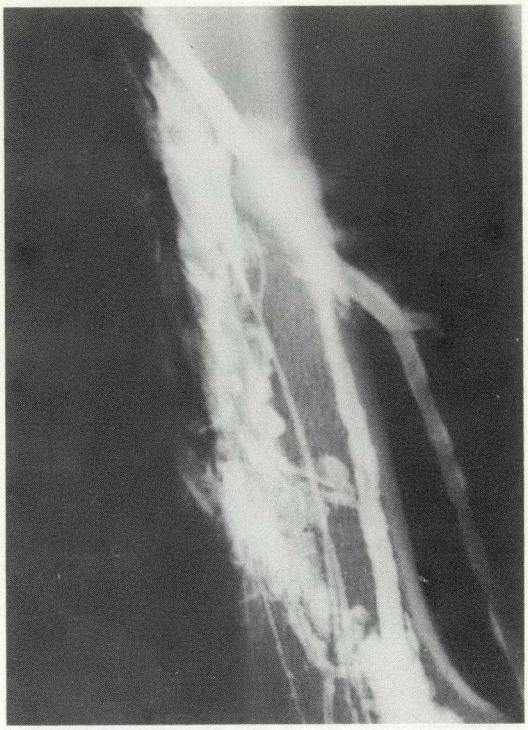

Fig. 6.—Marked extravasation and filling of perivascular spaces; another collateral pathway.

Fig. 7.—Lymphedema secondary to malignant metastases in the lymph nodes of the right external iliac region.

Hyperplasia, indicating primary lymphedema, is present in 10% to 20% of the cases.[3, 4] The channels are numerous, large and tortuous, usually more so than in secondary lymphedema. The edema is presumably due to an incompetence of the valvular system in those abnormal channels.[5] It is in these cases that the volume of oil required to fill such systems increases the possibility of clinically significant pulmonary oil embolism.

True aplasia would seem to be a very rare congenital anomaly and the apparent absence of superficial lymphatic trunks does not necessarily mean that deeper trunks are not available. Three of our cases were classified as due to aplasia but incisions were made only on the dorsum of the foot. We realize it is quite possible that channels could have been found by injecting the blue dye in the retromaleolar regions.

Increased fragility or porosity of the walls of the channels has been invoked as a possible cause of lymphedema.[6] However, the extravasation may be the result of increased pressure and higher speed in the course of making the injection rather than due to a defect in the lymphatic wall, so that careful interpretation is necessary.

Filariasis affects two hundred million people in the world today and is the most frequent cause of secondary lymphedema.[7] On the North American continent, where filariasis is rather rare, malignant disease is a much more common cause. In fact it is not unusual that edema is the first manifestation of a malignant process. Lymphography often will determine the site and nature of the lymphatic obstruction, it will help in planning the treatment and allow evaluation of the response to this treatment. A clinical diagnosis of primary lymphedema may even be altered to the secondary type if lymphography demonstrates obstruction.

On the radiograph, edema secondary to previous episodes of lymphangitis may be indistinguishable from primary lymphedema[8] and in such cases a clinical history often decides the issue. Abnormal diffusion of the blue colouring agent into lymphatic spaces of the dermis merely indicates lack of patency of some or all the major trunks. This phenomenon of dermal staining can be seen in primary lymphedema but also in the secondary form, especially in those cases which are due to repeated bouts of lymphangitis.

The route of injection we have selected is the lymphatic trunks that parallel the greater saphenous vein and therefore allows direct assessment of this system only; the lesser saphenous and the deeper femoral systems are usually not opacified by our method. In most instances, however, indirect evaluation of these latter two systems is possible from the lymphographic findings in the greater saphenous system.

Conclusion

Physiological conditions are difficult to ensure during lymphography of the lower extremity since technical factors are apt to modify the appearance of the lymphatic system. As a result, in primary lymphedema careful evaluation of the roentgenographic findings is highly necessary. The practical contribution of lymphography in edema of the lower extremity lies mainly in the detection of lymphatic obstruction and the demonstration of its cause.

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BIPOLAR DIATHERMY*

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Summary: The authors present an explanation of the manner in which diathermy produces its effects. The advantages and special uses of bipolar diathermy are explained. Desirable characteristics of an improved machine are listed and translated into three electronic terms. These are choice of wave form, stability of voltage output and floatability. A machine with these electronic features has been built and tested both in the laboratory and in the operating room. The authors hope that these analyses will encourage surgeons in the different specialties to use bipolar diathermy, and also that they will help surgeons in evaluating any machine whose purchase they are considering.

Résumé: Un neuro-chirurgien et un ingénieur en électronique ont fait des études sur la diathermie bipolaire, ses avantages et le mécanisme de coagulation ainsi produite.

Les caractéristiques d'une bonne machine à diathermie bipolaire sont présentées en trois caractéristiques électroniques importantes et sont considérées comme étant: le choix de l'onde électronique, la stabilité de la source de courant de radiofréquence et une machine à diathermie bien flottante, c.a.d. que le courant n'a pas tendance à s'enfuir à la terre (ground).

Les résultats obtenus expérimentalement et cliniquement justifient l'utilisation de cette technique dans diverses spécialités.

DIATHERMY causes its effect through radiofrequency (RF) current. Every time an RF wave passes through the tissue (and it does this *at least* 70,000 times per second) the molecules tend to turn so as to lie along its path much as a compass needle will point towards magnetic north. In the next fraction of a second, however, the polarity of the wave reverses. The molecules then tend to turn 180° so as to align themselves in their original position. This tendency to turn back and forth with each oscillation of the RF current acts as a source of internal friction, which produces heat and this coagulates the tissue.

This phenomenon is known as dielectric loss, but there is another factor which is of importance. The RF current is driven by a voltage which is often large. Owing to its electrical resistance the tissue then resembles the element of an electric fire—both heat up when the current is switched on. Hence the effect of conventional diathermy is to coagulate tissue by heat, on the one hand internally from molecular movements of dielectric loss and on the other hand by the direct effect of the voltage of the RF current and the resistance of the tissue.

Conventional unipolar diathermy causes a sphere of intense coagulation around the end of the operator's instrument. As the distance from that point increases and the current disperses, the amount of coagulation diminishes. There is no fundamental difference between coagulating and cutting diathermy except that in the latter the power is much greater. During cutting with diathermy the tissue is actually vaporized instead of being merely charred.

If diathermy is used extensively so much damaged tissue may be left in the wound that healing may be retarded and infection promoted. Complications of diathermy, such as explosions and burns, are potentially serious.[1] Diathermy is often unsatisfactory for sealing large vessels and, most important, the spread of coagulation effect that occurs may prohibit its use in certain areas where damage to nearby structures cannot be risked. Thus it is often dangerous to use diathermy near an important nerve or vessel (e.g. during parathyroid surgery) or in a tissue such as the testis connected to the body by a small structure constituting a high resistance path, with the concomitant risks of thrombosis.

Greenwood[2, 3] first used forceps where the blades were insulated from each other and since then other bipolar coagulators have been described.[4] Theoretically, in these machines the current will pass between

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the forceps points, and therefore only the tissue directly gripped in the jaws of the instrument will be coagulated.

Specificity of action in diathermy is very desirable. If really well-controlled coagulation can be produced, then the number of areas where diathermy can be used is increased. Ophthalmic, otolaryngological and neurological surgeons are most likely to find uses for a bipolar coagulator and, indeed, many of these are already aware of its advantages. Apart from these specialists, many of whom tend to use magnification during operation, there will be other surgeons who would at some time find valuable the use of safe and precise diathermy apparatus.

For these reasons we attempted to describe the features that a surgeon would find desirable in a bipolar coagulator. These have been translated into electronic terms, and we have built a number of machines to test whether these features can be provided.

Objective

Desirable characteristics of an improved machine are:

(a) There should be no stimulation of neuromuscular tissue during use. A muscular twitch occurring during the course of fine work in an operative field, perhaps viewed through a loupe or a microscope, would be undesirable. (There is also a theoretical objection to using a wave form to which nervous tissue is sensitive.)

(b) Only the structure that is grasped between the points of the forceps should be coagulated. This accuracy of action without significant spread of RF damage to neighbouring structures is a unique feature of a successful bipolar coagulator and distinguishes bipolar from unipolar machines.

(c) Shorting of one or both forceps blades higher up the shaft, when it does occur, should not affect the performance of the machine or damage the tissue causing the short circuit.

(d) Tissue touching the outside of the forceps point should not be affected. If two structures lie in contact with each other and it is desired to coagulate only one, then the other must be safe even if it does touch the outside of the forceps.

(e) The machine should produce the same voltage at each dial setting irrespective of the load, i.e. the type of tissue. Sometimes conventional diathermy works poorly on fat. If the dial is turned up to help at this stage, then as soon as muscle is reached coagulation may become violent.

(f) The machine should coagulate equally well in dry and wet conditions. This is a point of particular importance to neurosurgeons whose operative field is likely to be flooded regularly with cerebrospinal fluid corresponding with the patient's respirations. Apart from this, it is customary to irrigate the forceps with saline during use so as to prevent them sticking to the tissue, and to reduce charring to a minimum.

(g) There should be no interference with other electronic equipment in the operating room.

(h) The machine should be safe and reliable.

(i) It should be cheap to produce and easy to service.

(j) It should be silent.

Results

We built machines using tubes rather than transistors because the former were readily available, cheap, and known to be practical as RF generators. We did not use spark-gap generators because they cause much interference, are inefficient and noisy, and produce a spiky non-repetitive wave form that makes design and measurements extremely difficult.

We found it relatively easy to achieve characteristics (g) to (j) listed above provided the machine was adequately grounded and screened. A remote switching device was used. Interference with other electronic devices did not occur, and tubes were both reliable and easy to replace if this became necessary.

Coagulators should be safe for both patient and operator. There are remarkably few regulations which apply to diathermy equipment with a rating of less than 50 watts, which includes most bipolar coagulators. Therefore certain precautions are necessary in the design and manufacture of some of these machines. For example some commercially available machines allow the full mains voltage of 110 volts (220 volts

in some countries) to pass through the foot switch. Other points to be avoided are listed in Table I.

We found that the characteristics (a) to (f) listed above were functions of three electronic factors. Although in practice they all mutually interact, they will be described singly to clarify the basic principles involved.

Wave form and frequency of the RF current.—Coagulation is achieved both by dielectric loss and by the actual voltage used to drive the current. The higher the frequency the more the molecules shimmer, and the greater the heat generated internally from this source. Spark-gap machines produce a rather low-frequency wave (about 1.14 mHz) with a large peak-to-peak voltage of about 550. The wave is damped and just as shock absorbers stop a car from swaying up and down after hitting a bump in the road so the oscillations quickly die away, being negligible at about 7 μsec. There is then a gap of complete silence for about 10 μsec before the spark gap fires again (Fig. 1). We chose a continuous RF wave form oscillating much faster (8 mHz) which eliminates the gap of electrical silence. Hence one can make the RF waves pass through the tissue seven times as frequently and, since the wave form is active continuously instead of less than half the time, maximum voltage can be lowered to one-seventh of that used in spark-gap machines.

There are several advantages to this arrangement. The effect of dielectric loss is made as great as possible and the effect of conduction is reduced, thus equivalent degrees of coagulation are achieved with a much lower voltage. Dielectric coagulation is much more localized in its action than conduction heating. The pure wave form makes suppression and screening easy so that electrical interference does not occur. Laboratory tests showed that neuromuscular tissue is insensitive to RF current at 8 mHz and a maximum of 80 volts peak-to-peak. It is unnecessary, therefore, to add any other complicated electronic circuitry to avoid neuromuscular stimulation. Fig. 2

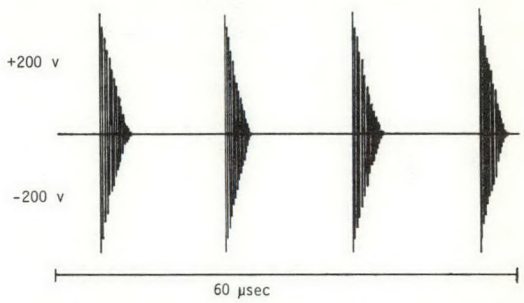

Fig. 1.—Diagram of a spark-gap-generated RF current. Note the initial high voltage, quick damping of the wave down to zero and long periods of electrical silence.

TABLE I.—UNDESIRABLE CHARACTERISTICS IN A BIPOLAR COAGULATOR*

Characteristic	*Defect in design responsible*
Poor floatability	Machines whose output coil is large compared with the driving coil Machines where the stray capacitances of the output coil are not symmetrically balanced about the earth (Floatability in a transistorized machine may be poor for these reasons)
Unstable voltage output	Machines whose output is controlled by crude resistance potentiometers
Neuromuscular stimulation occurs	Spark-gap machines as well as some others whose oscillator produces a modulated envelope of RF that follows the 50 to 60 Hz sine wave of mains supply Machines whose RF is in the KHz range (Note: some transistorized machines prevent stimulation by using a gate instead of raising the RF)
Noisy operation: interference with electronic monitoring equipment in the operating room	Spark-gap machines 60 Hz modulated envelope machines Poorly screened machines
Low safety level	Overheating Electronic circuitry partially exposed Sparking Patient not separated from the machine by capacitors Not watertight Mains voltage through a foot switch

*Technical details of laboratory methods and of calculations involved are being published separately.[6]

shows a comparison of the two wave forms discussed.

Stability of voltage output.—With some bipolar coagulators the voltage changes according to the load (thickness and type of tissue) across the forceps point. This fluctuation of voltage caused by different loads accounts for the different speeds at which these machines coagulate different tissues even if the dial setting remains unchanged. These machines usually use crude resistance potentiometers to control power output and these, paradoxically, produce less power at high dial settings under heavy load. In other words if the tissue is not coagulating as the surgeon would wish, and he requests that the dial be turned up to a higher setting, then the machine produces *less* power.

To overcome this disadvantage and also to ensure that the machine will work as well in wet as in dry conditions we used a closed-loop feedback system. The output voltage is sensed, and then a comparison is made between what the output voltage actually is and the level chosen according to the dial setting. If these two are very different then the machine automatically produces more or less power as appropriate.

Floatability.—The mains electricity supply is grounded to earth at the generating station. This explains why one gets a shock if one touches a live electrical wire. Current flows through the observer to earth and back to the grounded wire at the generating station to complete the circuit. This grounding to earth is not seen with a battery. If one terminal of a battery is connected to the ground the battery will not discharge to earth—the output is floating and will only return to itself. A battery-driven machine would be ideal but is impractical. It is therefore necessary to devise a mains-operated RF generator which produces a floating output that does not ground to earth although the mains supply is grounded.

If a really high quality floating output can be achieved then there is no possibility of coagulation damage anywhere except between the forceps points where it is required. In spite of the fact that the patient is grounded to earth in the operating room, and is likely also to be connected to monitoring equipment which provides additional grounding connections, a truly floating RF supply will only return to itself and will not avail itself of the electrical path through the patient to ground. The power will be concentrated on the inner surface of the forceps point as this constitutes the shortest path for the current to complete the circuit. Spreading coagulation damage will be reduced to a minimum and this arrangement will not be significantly affected by shorting the forceps or touching structures with the outside of the points.

In the laboratory we measured the floatability of an average spark-gap machine and found that 50% of the power of the 550-volt surge grounded to earth. Eventually we managed to reduce our loss to less than 5%. House and Hitselberger[5] have shown that diathermy current tends to spread along blood vessels as these are the paths of least resistance. Presumably this effect is undesirable and to avoid it a high degree of floatability is essential.

Summary and Conclusions

An explanation is given of how diathermy causes its effects, and the advantages of bipolar coagulation are presented. Working together, a neurosurgeon and an electronics engineer have explored this field and tried to translate surgical needs into electronic terms. Against this background we drew up the characteristics that we believed a good surgical bipolar diathermy unit should possess. These were converted into the appropriate electronic features and some

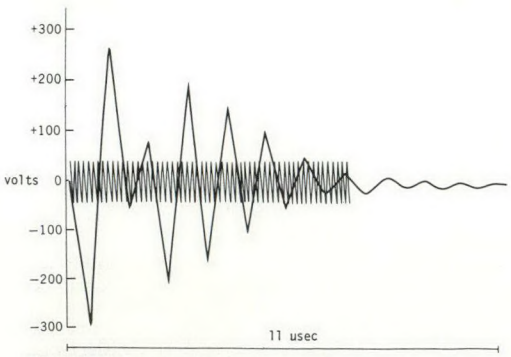

Fig. 2.—Comparison between the continuous RF current and the spark-gap-generated current. Because there is no gap of electrical silence (compare Fig. 1), and because the frequency is much higher, the power from the purer, more manageable, continuous tracing is the greater.

prototype machines were built and tested.

Our last prototype has been in use for 18 months in the operating room (Fig. 3). It has been found that bipolar coagulation increases the range of operative procedures that may be undertaken with confidence. For example, intrinsic spinal tumours and tumours of the conus medullaris and cauda equina may be operated on more easily and safely. Vascular neurosurgery, whether of the spinal cord or of the circle of Willis, has also been facilitated.

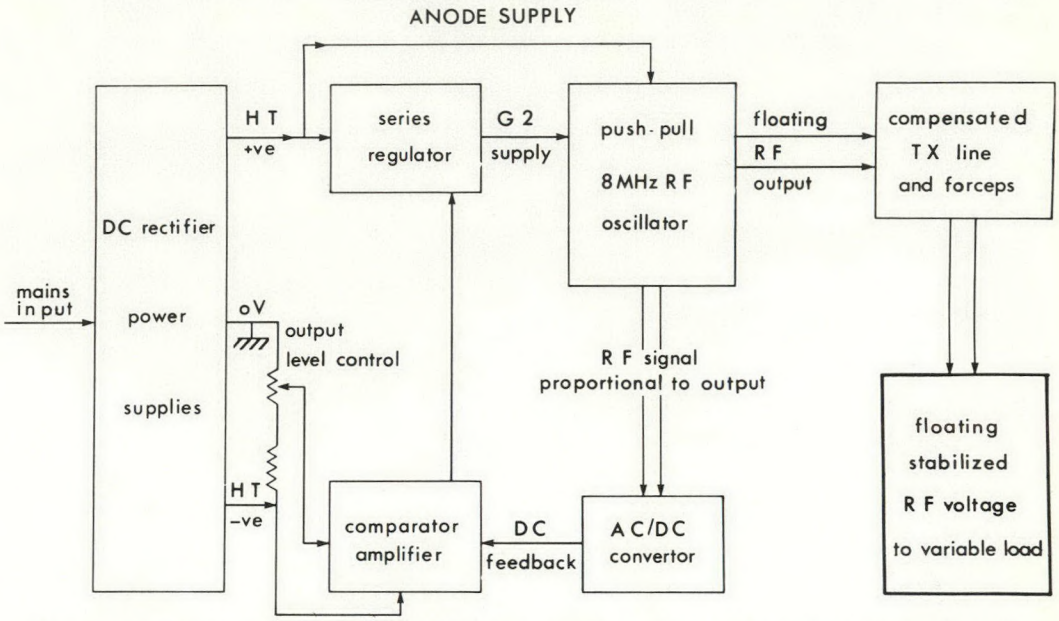

Fig. 3.—Block diagram of our latest bipolar coagulator. First, the output coil consists of one turn only, which greatly reduces the stray capacitances, and what few there are have been symmetrically balanced about the earth. Second, the oscillator circuit consists of two 12-watt pentodes in a cross-coupled circuit. This "push-pull" arrangement means that any current flowing to ground through the stray capacitances from one-half of the driving tank coil will meet an equal but opposite current from the other half, and these two will tend to cancel out. The transmission line, of course, requires capacitors to compensate for its inductance. These help to maintain the voltage at the forceps tips at a constant level. HT = high tension voltage; oV = ground (earth); G2 = tube grid voltage; TX = transmission line.

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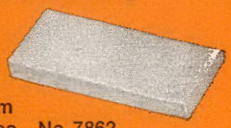

Sterile Sponge,
size 200
80 x 250 x 10 mm
box of 6 sponges No. 7862

for general surgery

Sterile Sponge,
size 100
80 x 125 x 10 mm
box of 6 sponges No. 7859

for general surgery

Sterile Sponge,
size 50
80 x 62.5 x 10 mm
box of 4 sponges No. 7858

specially prepared for dry application and emergency hæmostasis

Sterile Compressed
Sponge,
size 100
80 x 125 mm
box of 6 sponges No. 7865

for general and neurological surgery

Sterile Sponge,
size 12-3 mm
20 x 60 x 3 mm
box of 4 sponges No. 7852

for general and neurological surgery

Sterile Sponge,
size 12-7 mm
20 x 60 x 7 mm
box of 4 sponges No. 7853
or jar of 4 sponges No. 7854

for use with Foley catheter

Prostatectomy
Cones,
size 18 cm
(7 in.) in diam.
box of 6 cones No. 7883

for use with Foley catheter

Prostatectomy
Cones,
size 13 cm
(5 in.) in diam.
box of 6 cones No. 7880

promote healing in chronic leg ulcers

Sterile Powder
jar containing 1 g No. 7876

oral hæmostatic for gastroduodenal bleeding

Non-Sterile Powder
box containing 10 g No. 7877

for dental surgery

Dental Pack,
size 2
10 x 20 x 7 mm
jar of 15 No. 7867

for dental surgery

Dental Pack,
size 4
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jar of 15 No. 7868

non-hæmostatic for repairing defects in dura and pleural membranes

Sterile Gelfilm
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envelope
containing 1 strip No. 7842

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Ophthalmic
Sterile Gelfilm
25 x 50 mm
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Precautions:
Gelfoam and Gelfilm are simple to use, and with conscientious observance of certain precautions satisfactory results may generally be expected where their use is indicated.

1. Gelfoam should be used discriminately in arterial bleeding because of the intra-arterial presence. It is advisable to suture and reinforce where possible.
2. Although Gelfoam generally serves its purpose well in the presence of hæmorrhagic blood dyscrasias, it should not be relied upon as the sole method of hæmostasis in such conditions.
3. Gelfoam should not be used to stop menstrual bleeding. In postpartum and menorrhagic bleeding it serves only as a temporary vaginal tampon.
4. Gelfoam must be in snug contact with the bleeding surface in order to be effective.
5. Use Gelfoam as sparingly as possible in order to minimize the amount of implanted foreign material.
6. Do not overfill cavities with Gelfoam.
7. Do not use Gelfoam in grossly contaminated wounds which are so deep that drainage is interfered with. However, it may be used for temporary hæmostasis in more superficial contaminated wounds, provided it is removed after it has served its hæmostatic purpose.
8. Avoid prolonged exposure of Gelfoam to contaminated air.

FACTORS ASSOCIATED WITH FAILURE OF LUMBAR SPINE FUSION*

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Summary: Twenty-eight World War II veterans were examined two or more years after a lumbar fusion. The success of operation was determined on the basis of a specially devised disability rating scale. One-third of the patients remained unemployed despite a solidly healed fusion. Degeneration of intervertebral discs above the fusion level and psychological disturbances are the main reasons for unsatisfactory results. It is recommended that the preoperative screening of patients include, along with other tests, a psychological assessment.

Résumé: Nous avons examiné 28 anciens combattants de la deuxième guerre mondiale deux ans au moins après une fusion lombaire. Nous avons évalué le succès de l'opération d'après une échelle de cotation de l'invalidité spécialement conçue à cet effet. Un tiers des malades sont restés chômeurs, malgré une arthrodèse solidement fixée. Les principales raisons susceptibles d'expliquer les résultats défavorables sont la dégénérescence des disques intervertébraux, au-dessus du siège de l'arthrodèse, et des troubles psychologiques. Il serait donc sage de faire figurer un test psychologique parmi la batterie d'épreuves auxquelles on soumet les malades en vue d'un dépistage préopératoire des candidats à l'intervention.

POSTERIOR lumbar spine fusion has been employed frequently in the treatment of low back pain after conservative management has failed to relieve disabling pain. Although the operation has made it possible for many patients to return to productive life, some remain disabled in spite of a solid fusion. The treatment of the so-called "failed back-surgery" patient is one of the most difficult clinical tasks facing the orthopedic surgeon.[1]

The results of posterior lumbar spine fusion vary, depending on the level fused and the criteria used in the final assessment of patients. Based on the solidity of fusion the success rate is 80% to 95%,[2-6] being somewhat lower when a two-level fusion has been performed. On the other hand, when the main factor in assessing the results is the state of employment two years after fusion, the success rate is only 40%.[7-9]

The causes for failure of posterior lumbar spine fusion to restore the patient to a useful life can be grouped into four categories: pathologic changes in the lumbar spine, psychological abnormalities, socioeconomic drawbacks and the influence of compensation.

Pseudarthrosis, degeneration of intervertebral lumbar discs at levels above the fusion, and narrowing of the lumbar canal due to bony overgrowth are commonly mentioned causes of failure of back fusion.[8] The finding of psychological abnormality in most patients with poor results following lumbar spine fusion has induced some to suggest that neurosis is a reason for failure of fusion.[8] It is obvious that a poor educational background and dependence on manual work constitute a major handicap to the patient with backache, significantly enhancing his disability. Similarly, compensation in the case of industrial accidents can contribute to disability following fusion.[7] The relative importance of various causes of failure is not clear and further studies are necessary to find out why spinal fusion relieves pain in some patients and not in others.

Our aim was to establish the success rate for posterior lumbar spine fusion in a veteran population by assessing the function of the lumbar spine and overall disability arising from backache. A rating scale for appraising the success of fusion in returning the patient to employment was developed. Furthermore, an attempt was made to identify the factors responsible for success or failure of fusion, with the object of using this information in the selection of candidates for lumbar spine fusion.

METHOD

Seventy-seven veterans underwent a

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Boucher-type lumbar spine fusion[2] at one or more levels for low back pain at Shaughnessy Hospital, Vancouver in the seven-year period 1962 to 1968. Of these, 28 patients appeared for re-examination from two to nine years after their last fusion. A complete physical, radiological and psychological assessment was made. In order to determine the total amount of disability arising from the back condition, a rating scale was devised (Table I). The sum of the scores assigned to various criteria was used to classify the patients in three groups: group I, the seven with the lowest scores (good result); group II, an intermediate group of 14 patients (fair result); and group III, the seven with the highest scores (poor result). We considered the results in the latter two groups as unacceptable.

RESULTS (Table II)

Chronology of the Disease

Although the patients were of similar ages at the time of examination, those in the group with the most favourable results had developed their symptoms later in life than the others and had a shorter time interval from the onset of back pain to their first fusion (Table III).

TABLE I.—SCORING CRITERIA FOR PATIENT CLASSIFICATION

Category	*Factor*	*Maximum score*
Work, pain	Reduced level of employment	1 or
	Discontinued work owing to low back pain	3
	Time lost in last two years	2
	Presence of pain	2
Examination	Impairment of:	
	Gait	2
	Lumbar flexion	2
	Lumbar extension	2
	Lateral flexion, left/right	2
	Straight-leg-raising pain	2
	Low back tenderness	2
Rating	Patient's opinion of results	2
	Patient's opinion of value of surgery	2
	Opinion of orthopedic examiner	4
Maximum (i.e. worst possible result)		27

TABLE II.—VARIABLES DISCRIMINATING BETWEEN THE GROUPS (PERCENTAGE)

Variable	*Overall*	*Group I*	*Group II*	*Group III*
Onset related to trauma	86	57	100	86
Single admission for problem	25	57	21	0
More than one fusion	25	30	40	43
Return to work in less than four months after fusion	28	43	36	0
DVA pension for back	68	28	78	85
Abnormal cervical or thoracic spine	32	0	35	57
Calf or thigh asymmetry	34	0	43	34
Sensory impairment	34	0	36	57
Contrast medium present	57	29	57	86
Single-level fusion (L5-S1)	39	86	36	0
Two-level fusion (L4-S1)	46	14	50	71

TABLE III.—CHRONOLOGY OF THE DISEASE (AVERAGE, YEARS)

	Group I	*Group II*	*Group III*	*Total*
Age at examination	50	54	55	53.3
Age at onset	33	27	26	27
Time interval between onset and fusion	9	18	15	15

Symptoms

Of the total, 11% (3/28) were symptom-free, all belonging to group I. Pain alone was the dominant symptom in 64% (18/28). Only 21% (6/28) had not had an attack of acute back pain in the last two years (71% in group I, none in group II). The pain was felt only in the back in 32%, predominantly in the back in 32%, equally in the back and legs in 11% and predominantly in the legs in 7%.

Trauma

There is a significant, direct relationship of trauma at onset to the severity of the back condition at follow-up.

Operative History

Multiple operations were associated with the groups with a poor score.

General Health

Twenty-one percent (6/28) admitted to no other health problems. There were more health problems among patients in the unsatisfactory groups.

Occupation

Of the total, 50% (14/28) were in full employment. None of group III patients but 86% of group I (6/7) were in steady employment. No conclusion could be drawn about any difference in occupation between the groups. A better result was associated with an earlier return to work after operation. On the other hand, the receipt of a Department of Veterans' Affairs pension was more commonly seen in the groups with poorer scores.

General Examination

Forty-three percent (12/28) demonstrated some abnormality on abdominal examination and 21% (6/28) on rectal examination, often in the form of coccygeal tenderness. These abnormalities were present mainly among patients with only fair and poor results.

Musculoskeletal Examination

Abnormality of the cervical and thoracic spine was found in 32%, but none of these patients was in group I. Similarly, abnormality of the lumbar curve, spasm and deficient tone of abdominal muscles, and localized back tenderness were found mainly in patients with poor results.

Neurological Examination

Positive neurological signs, such as limited straight-leg-raising, thigh or calf muscle wasting and sensory impairment, were found only in patients in the fair and poor groups.

Radiological Findings

The presence of radiopaque contrast medium, indicating investigation for disc prolapse, was found mainly among patients with fair and poor results, which is not surprising if their neurological abnormalities are considered. No instance of pseudarthrosis was seen in this series although four patients had previously been operated upon for this condition. Kissing vertebral spines were seen at one level in 31% (10/28) and at two levels in one patient. The presence of this did not correlate with the results nor with the presence of spinous tenderness in the same patients.

Degenerative changes (traction spurs, osteophytes, narrowing of the upper four lumbar intervertebral spaces) correlated well with the grouping of the patients, being more pronounced in those with the poorest results. Single-level appeared to be more successful than two-level fusion.

Psychological Findings

The mean I.Q. using the Wechsler Adult Intelligence Scale was 107.2, slightly higher than expected for a random sample. There was no difference in intelligence or educational background between the groups.

The differences in the Minnesota Multiphasic Personality Inventory profiles, particularly in four of the scales, are striking (Fig. 1). Group II shows the "conversion V" configuration of the neurotic triad (scales 1, 2 and 3), the elevation of 1 and 3 (hypochondriasis and hysteria) being greater than 2 (depression). In group III there is elevation of hysteria, hypochondriasis and depression and a low ego strength compared with the normal values for group I. In 57% of the patients there was a history of psychopathology, ranging from schizophrenia

to alcoholism, but this was uniformly distributed among the three groups.

Discussion

The validity of our conclusions in this study is affected by the selection, based on availability, of this predominantly male veteran sample. All patients had a similar socioeconomic background; many were eligible for pension.

With solidity of fusion as the sole criterion for success no case could be judged as a failure since all these patients had a solid fusion when assessed (some had had a previous repair of pseudarthrosis); this is in agreement with many published reports.[2] However, if the degree of disability is considered, fusion failed to enable 50% of patients to return to a functional life, while one-third were not working. This corresponds with the results in studies where the major criterion for success of fusion is a return to employment.[7]

The poor results in this series might in part be owing to self-selection, since it is possible that only patients with painful backs made themselves available for re-examination. However, in a review of the charts of all 77 patients who had had a fusion at least two years previously, we discovered that more than one-third of those patients were unemployed and had disabling low back pain.

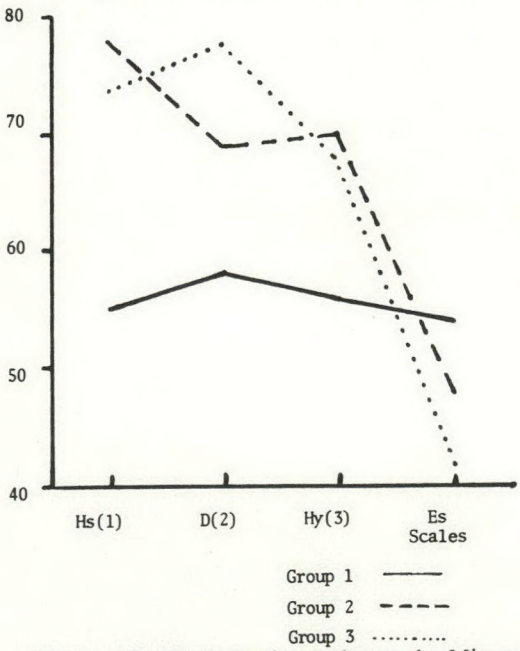

Fig. 1.—The discrimination scales on the Minnesota Multiphasic Personality Inventory. Hs = hypochondriasis; D = depression; Hy = hysteria; Es = ego strength.

We believe that the presence of advanced generalized disc degeneration and the existence of psychological abnormalities are major factors responsible for unsatisfactory results from lumbar fusion. In addition, the availability of compensation, long duration of symptoms before fusion, history of several back operations and the presence of other health problems all contribute to the overall disability following fusion.

The careful analysis of radiographs revealed more advanced degenerative changes of the lumbar discs among the patients with poor results. It can be assumed, therefore, that in these cases either fusion had not included all the symptomatic discs or increased stress on the discs above the fusion level had accelerated the degenerative process. These patients were more likely to have had a two-level fusion.

The psychological assessment at follow-up demonstrated increased neurosis, objectively measurable, in the patients with poor surgical results. We do not know whether the neurosis developed before or after the fusion. According to Beals and Hickman[7] and White,[9] who studied psychological factors in low back pain, a pre-existing neurosis precludes successful surgical treatment. It is quite possible that the patients in our study with poor results had preoperative neurosis which interfered with the success of surgical treatment.

Most patients receiving compensation were in the groups with unacceptable results. Since the majority of these patients were eligible for compensation it may be assumed that the availability of a pension delayed rehabilitation following fusion. Beals and Hickman,[7] White[9] and others[6, 8] have found that the results of lumbar spine surgery are much poorer when compensation is provided. Denker mentions a better rate of return to work in compensation patients when they receive a lump sum settlement than when regular continuing instalments are paid.[10]

The degree of success of lumbar fusion is inversely related to the duration of low back pain prior to fusion; patients with

poor results had a longer history of pain. Persistent backache for many years before fusion had rendered these individuals less physically fit and more neurosis-prone, thus making successful rehabilitation following lumbar fusion less likely.

Patients with disabling backache following fusion had, in addition, other health problems, affecting particularly the genitourinary and gastrointestinal systems. It is possible that persistent back problems and other disabling illness reflect premature ageing of lumbar discs as well as of other body systems.

Conclusions

The production of solid lumbar fusion is not the only prerequisite for alleviation of disabling low back pain. Lumbar disc degeneration limited to only one or two levels (included in the fusion), freedom from neuroticism and a short history of back pain are additional equally important factors for a successful operation, in the sense of relieving disability. The availability of compensation and the presence of disease states affecting other body systems contribute to disability following fusion. The history of repeated operations is a sign of a poor prognosis. One can assume that if a first operation was not effective in relieving the patient's symptoms, further surgical attempts to control back pain will be equally unsuccessful.

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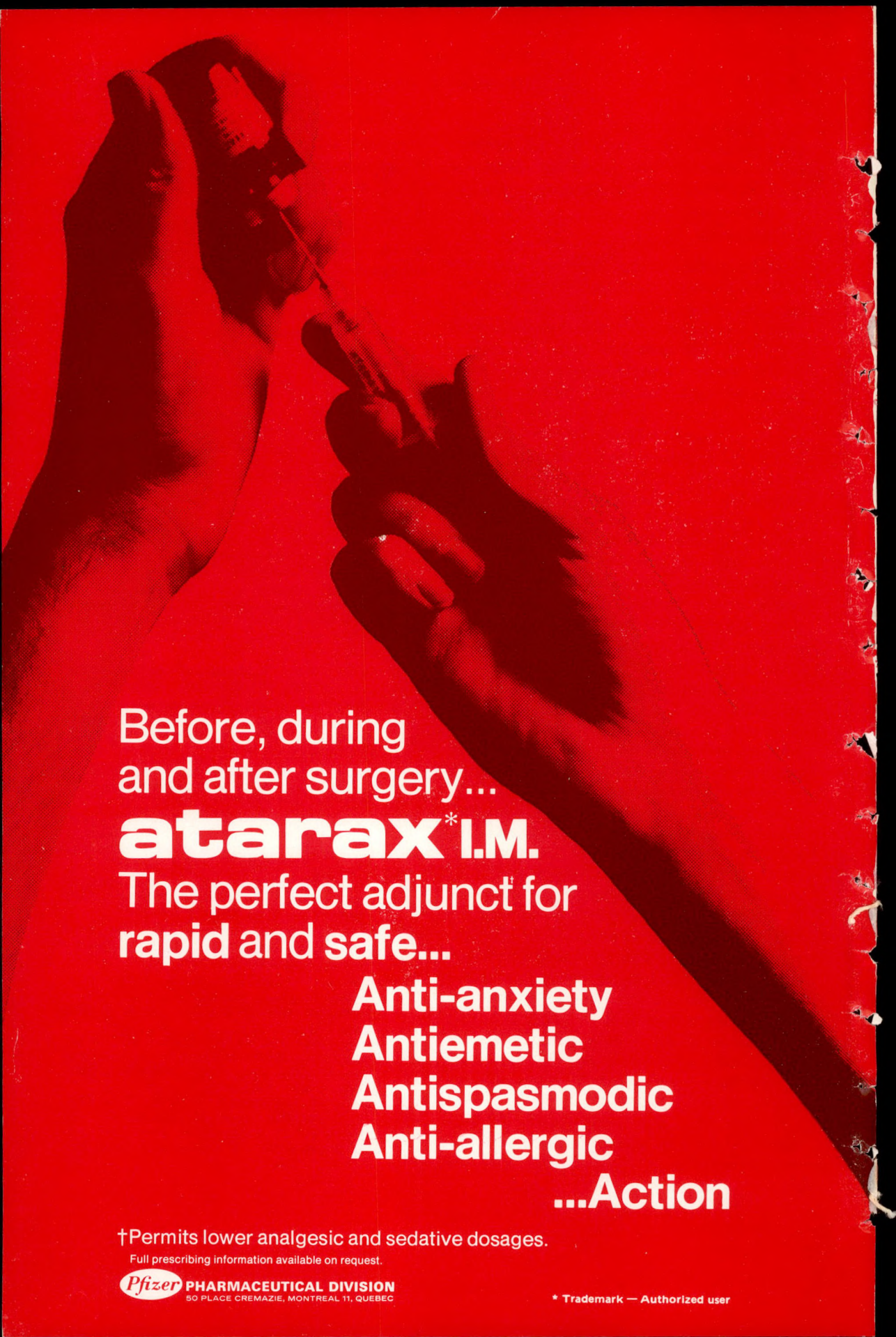

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STERNAL RESECTION AND REPLACEMENT WITH REINFORCED SILASTIC SHEETING

W. J. ENGELBRECHT, M.D., R. BISARYA, M.D., L. BURR, M.D. and G. D. SAXTON, M.D., F.R.C.S.[Edin. & C],* *Vancouver, B.C.*

Summary: A case is presented of sternal resection for solitary chondrosarcoma and replacement with Dacron-reinforced Silastic sheeting. The advantages of this material are its excellent acceptance by body tissues combined with its rigidity. The latter quality provides the chest wall with immediate and adequate stability. General technical precautions are to be taken as with all prosthetic materials.

Résumé: Les auteurs présentent un cas de résection sternale pour chondrosarcome solitaire et où le sternum a été remplacé par une matière de Silastic renforcé par du Dacron. Les avantages de cette matière: son excellente acceptation par les tissus et sa rigidité. Cette dernière propriété confère à la paroi thoracique une stabilité immédiate et très suffisante. Les précautions techniques générales à prendre avec cette substance sont les mêmes que celles qui concernent l'usage chirurgical de tous les matériaux de prothèse.

THE purpose of this paper is to review the methods of sternal replacement described in the literature and to add our own experience with the use of reinforced Silastic sheeting.†

CASE REPORT

A 73-year-old housewife was admitted to the Vancouver General Hospital on December 22, 1972 because of a progressively painful swelling of the sternum. She had noticed this mass for six months, and in the three weeks before admission it had become painful and she thought it had increased in size.

In 1969 she had experienced pain in the right hip and the radiographic appearance was compatible with Paget's disease of the right innominate bone. Radiographs of the chest at that time were unremarkable. The only abnormality on laboratory investigation was an elevated level of serum alkaline phosphatase of 35 King-Armstrong units (normal 3 to 13).

Physical examination revealed an ovoid, hard, immobile tender mass in the mid-sternum, measuring 5 x 5 cm. Radiologically, the lesion was noted to extend anteriorly and posteriorly from the sternum and to contain mottled calcifications.

An incisional biopsy was performed and the diagnosis of a well-differentiated chondrosarcoma was established. Subsequently the xiphoid and entire body of the sternum together with the adjoining costal cartilages and intercostal structures were resected *en bloc* (Fig. 1).

A piece of reinforced Silastic sheeting (0.08 inches thick) was tailored to fit the defect. The sheeting was anchored to the remnants of the costal cartilages and to the intercostal muscles with fine silk mattress sutures. Polyethylene tube drains were placed on the anterior and posterior surfaces of the sheeting and brought externally through separate stab wounds. The pectoralis major muscles, subcutaneous tissue and skin were then approximated (Fig. 2). The drains were removed 48 hours after operation.

Convalescence was smooth, without occurrence of infection, seroma or respiratory prob-

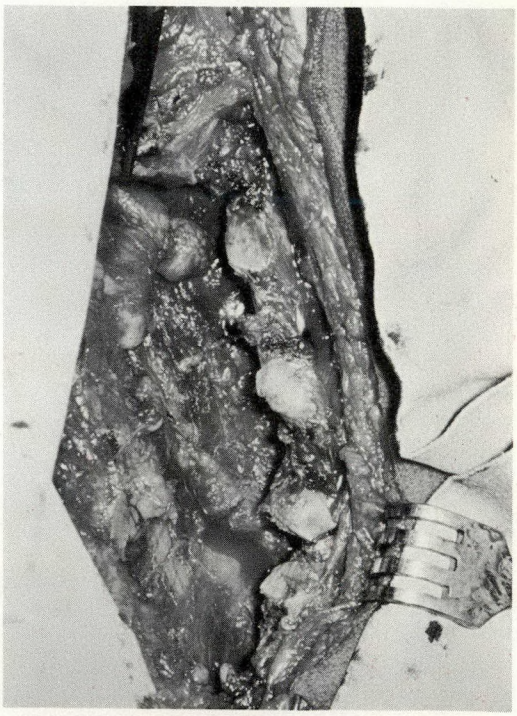

Fig. 1.—The defect following sternal resection.

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†Dow Corning Company, Chicago, Ill. 60645.

lems. The patient was discharged three weeks after the operation and has continued to do well.

Discussion

Although in some series the solitary plasmacytoma was found to be the most frequent tumour of the sternum,[1] the chondrosarcoma is the most common primary malignant tumour of the chest wall and the most significant[2] in relation to surgical resection of the sternum.

Adequate resection of this malignant tumour would necessarily result in a serious defect in the chest wall with its attendant complications:[3]

(1) Sucking chest wound. This may be overcome by an airtight closure of the skin and soft tissues (with or without flap mobilization).

(2) Mediastinal flutter and paradoxical respirations. The harmful effect on ventilation can be avoided by performing a type of repair that provides chest wall stability.

(3) Potential infection and fluid accumulation. The likelihood of these complications can be minimized by meticulous hemostasis, obliteration of potential dead spaces by tissue flaps, short-term drainage and use of broad spectrum antibiotics.

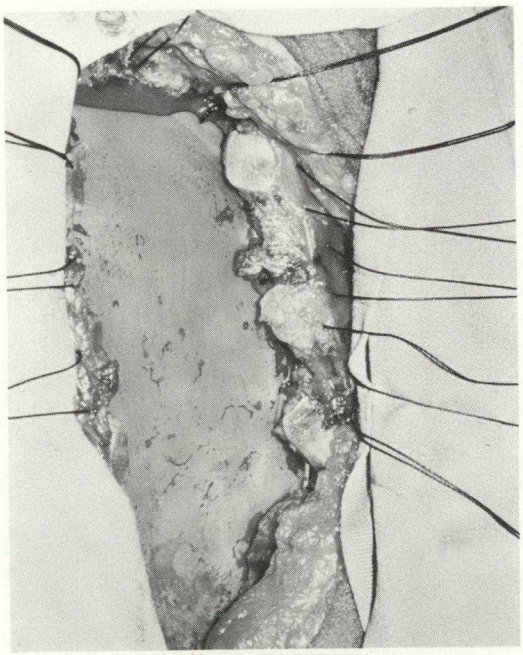

Fig. 2.—The Dacron-reinforced Silastic sheeting sutured in place.

The qualities of the ideal prosthetic material for replacement of chest wall defects (as enumerated by Le Roux[4]) are: (1) ability to provide chest wall rigidity, to prevent paradoxical respiration and protect the underlying viscera; (2) inertness, to ensure tolerance by the host and incorporation into the body without major tissue reaction; (3) malleability, to allow manipulation and tailoring to fit the defect, the size of which is not predictable; (4) radiolucency, to allow the underlying viscera to be clearly visualized by x-ray.

The acrylic resin used by Le Roux possessed most of the characteristics of the ideal prosthesis except that it was not incorporated into the host satisfactorily. Alonso-Lej and De Linera[5] successfully overcame this problem by combining the acrylic resin with Marlex mesh. This was well tolerated and was incorporated into the host's tissues; however, it lacks the rigidity of the acrylic resin.

To simplify this problem we have used Dacron-reinforced Silastic sheeting to minimize elongation or stretch and permit easy fixation of the material by sutures. This reinforced silicone polymer meets all the Le Roux prerequisites, is simple to use, readily available and can be sterilized by autoclave. It is superior to Marlex mesh in having adequate rigidity to stabilize the chest wall, while at the same time being well accepted by the body tissues.

As well as the importance of observing the general precautions used with all prosthetic materials we would emphasize meticulous techniques, scrupulous asepsis, fine suture material and short-term postoperative drainage.

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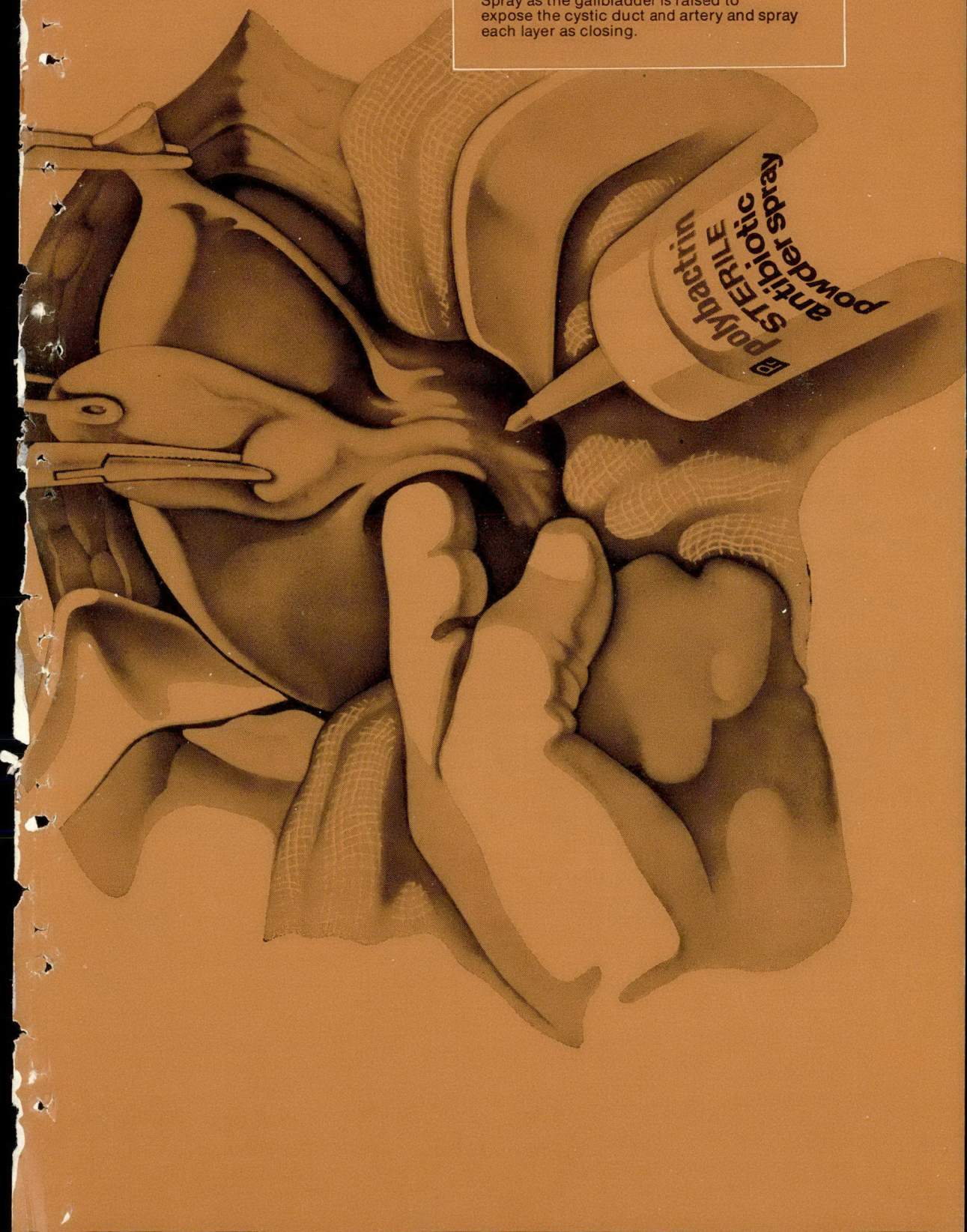

LA PRÉPARATION AU TRAITEMENT CHIRURGICAL DE L'HYPERTHYROÏDIE À L'AIDE DU PROPRANOLOL: ÉTUDE DE 15 OBSERVATIONS*

A. Z. EL-KHODARY, M.D., C. THIFFAULT, M.D., F.R.C.P.[C], L. DESCHENES, M.D. et JEAN COUTURE, M.D., F.R.C.S.[C], F.A.C.S.,
Québec, P.Q.

Résumé: L'utilisation du propranolol comme seul agent préparatoire à la chirurgie fait l'objet du présent travail. Afin d'évaluer l'efficacité de cette méthode de traitement, 15 patientes, dont le diagnostic avait été confirmé par le pourcentage de captation de l'iode radioactif et les niveaux de la thyroxine sérique, ont été étudiées suivant un protocole établi à l'avance. Propranolol a été donné par voie buccale à la dose de 40 mg/6 h chez la plupart des patientes, la dose quotidienne variant considérablement suivant les réactions individuelles et les modifications des signes d'hyperthyroïdie.

Chez la plupart des patientes, les signes d'hyperthyroïdie ont diminué très rapidement: dès les premières doses de médicament on a observé un ralentissement du pouls qui s'est normalisé en général moins de trois jours après le début du traitement. De même, les autres signes d'activité adrénergique tels que la transpiration, l'hyperkinésie, la chaleur de la peau, et les tremblements périphériques ont complètement disparu dans la même période. En conséquence, la période post-opératoire n'a duré que 5.6 jours en moyenne chez toutes nos patientes.

L'intervention chirurgicale a consisté en une thyroïdectomie subtotale conventionnelle et s'est déroulée de façon normale. Le chirurgien a noté que les glandes étaient fermes et n'étaient pas plus vascuralisées que les glandes préparées de façon conventionnelle. Les résultats immédiats ainsi que les résultats éloignés du traitement chirurgical ont été tout à fait satisfaisants. Après une période d'observation de 10.6 mois en moyenne, l'état clinique des malades et les épreuves de fonction thyroïdienne démontrent bien l'efficacité de cette méthode de préparation.

En définitive, les résultats chez ces 15 patientes semblent indiquer que propranolol est un médicament sûr, a une action rapide, et permet de raccourcir considérablement la période de préparation chez les malades souffrant d'hyperthyroïdie.

Summary: The administration of propranolol has been used as the sole means of preparation for thyroidectomy in hyperthyroidism. To evaluate further the safety and efficacy of this method we studied 15 hyperthyroid patients. The diagnosis of hyperthyroidism was confirmed biologically by ^{131}I levels of T4 and T3. Propranolol was given orally at four- to six-hour intervals to a total dose ranging from 206 to 659 mg/24 hr. The preoperative preparatory period varied from three to five days.

Pentothal was used for induction of anesthesia except in two patients in whom Valium was used; halothane and oxygen were used for maintenance. During induction only one patient developed bradycardia which responded to intravenous atropine. In all patients the surgeon found the gland firm, easily resectable and not unduly vascular.

Postoperatively all patients received propranolol perfusion at the rate of 1 mg/hr for 12 hours. The drug was then given orally at the preoperative dose, gradually reducing the amount until it was discontinued by the fifth day after operation; this corresponds with the duration of our calculated T4 disappearance interval of 5.3 days. T-wave changes were noticed in most patients on the third day after operation. Vectocardiography showed no evidence of ischemia. In all patients any changes noticed had returned to normal before discharge. Follow-up one year later showed that two of the 15 patients had developed hypothyroidism. The electrocardiogram was normal in all.

It is concluded that propranolol when used alone is safe and efficient for the preoperative preparation of hyperthyroid patients.

Le traitement chirurgical de l'hyperthyroïdie n'a pas subi de modifications appréciables depuis plusieurs années. De même, la préparation des malades à l'opération est demeurée sensiblement la même, soit l'administration d'antithyroïdiens de synthèse pendant plusieurs semaines et de l'iode pendant les quelques jours précédant l'intervention. Bien que cette méthode jouisse d'une grande faveur auprès des chirurgiens et des endocrinologues, il n'en reste pas moins qu'elle présente certains désavantages, dont

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l'un des plus importants est la période assez longue de préparation requise avant l'opération.

Depuis plusieurs années, l'emploi de médicaments anti-adrénergiques a été suggéré assez fréquemment dans le traitement de la crise thyroïdienne. A la suite des travaux de Brewster *et al,*[1] il a été démontré assez clairement que la thryrotoxicose reproduisait, jusqu'à un certain point, les effets secondaires à une augmentation de l'activité du système nerveux sympathique. Le rôle des récepteurs béta dans la production des symptômes de l'hyperthyroïdie a été démontré abondamment par Marsden et ses associés, et plusieurs autres[2-4] qui, par ailleurs, ont traité avec succès les diverses manifestations de la crise thyroïdienne par le blocage pharmacologique de ces récepteurs. De même la reproduction de certains symptômes associés à l'hyperthyroïdie tels que la transpiration, la température, la vaso-dilatation et l'augmentation du pouls, a été observée après la stimulation des récepteurs béta.

L'utilisation du propranolol comme antagoniste des récepteurs béta a été préconisée par Black *et al* en 1964.[5] Peu après, l'efficacité de ce médicament dans le contrôle des manifestations cliniques de la crise thyroïdienne et de l'hyperthyroïdie a été soulignée par quelques investigateurs.[6-8]

Ce n'est qu'en 1968 que le propranolol a été utilisé comme agent préparatoire à la chirurgie, en association avec l'iode par un groupe d'Afrique du sud.[9] Enfin, tout récemment, soit en juin 1973, un rapport d'un groupe de Washington faisait état des résultats très satisfaisants du traitement chirurgical fait chez 20 patients préparés uniquement avec le propranolol.[10]

Étude Clinique

Notre travail porte sur 15 patients, préparés à la chirurgie avec le propranolol et traités dans la section d'endocrinologie du département de médecine et le département de chirurgie de l'Hôpital du Saint-Sacrement à Québec. Il s'agit de 15 femmes, dont l'âge moyen est de 27 ans, la plus jeune ayant 15 ans, et la plus vieille 43. Bien que deux patientes aient reçu au moins un an auparavant des antithyroïdiens de synthèse, aucune d'entre elles n'avait été soumise antérieurement à un traitement chirurgical.

Afin d'obtenir une évaluation juste de cette méthode, un protocole, préparé à l'avance et réalisé dans l'unité métabolique de l'Hôpital du Saint-Sacrement, Québec, nous a permis d'avoir un bilan complet de chaque patiente, incluant toutes les données biologiques soit le *protein-bound iodine,* le T4, la captation de l'iode radioactif à quatre et 24 heures et le scintigramme thyroïdien. Le diagnostic de l'hyperthyroïdie a été confirmé dans tous les cas par les résultats de ces examens. Durant cette période d'observation, les signes importants à noter chez de tels patients, soit le pouls, la respiration, la tension artérielle, la transpiration, et les signes oculaires ont été notés fréquemment. Chez ces patients, l'asthme bronchique a été une contre-indication à ce traitement.

Propranolol par voie buccale a été donné à la dose de 20 mg/6 h chez les premières patientes et par la suite à la dose de 40 mg/6 h chez la plupart des autres patientes. La dose quotidienne a varié considérablement suivant les réactions individuelles et les modifications des signes d'hyperthyroïdie: en général, la dose moyenne a été de 237 mg avec des variables de 206 à 659. La période pré-opératoire a duré en moyenne 5.6 jours, mais n'a duré que deux jours chez deux malades.

La diminution rapide des signes d'hyperthyroïdie a été notée chez la plupart des patientes. Le plus souvent, un ralentissement du pouls a été noté dès les premières doses de propranolol; cet effet s'est poursuivi jusqu'à normalisation du pouls, assurant ainsi un pouls stable jusqu'au jour de l'opération. La tension artérielle a subi quelques modifications très mineures, mais la température est demeurée normale. L'intervention chirurgicale n'a été faite qu'après stabilisation non seulement des signes vitaux mais aussi des signes accessoires d'activité adrénergique, tels que la transpiration, l'hyperkinésie, la chaleur de la peau, et les tremblements périphériques. Chez trois patientes, une perfusion d'Isuprel a été faite 24 heures avant l'opération afin de déterminer plus objectivement l'efficacité du blocage des récepteurs béta par le propranolol. La dernière dose de propranolol a été donnée deux heures avant le début de l'intervention.

Traitement Chirurgical

Concernant l'anesthésie, l'induction des patientes a été faite avec le pentothal sauf chez deux patientes où le Valium a été utilisé à cause d'une histoire antérieure d'allergie aux barbituriques. Ces deux patientes ont présenté dans la période post-opératoire immédiate des symptômes pseudomyasthéniques assez importants, soit dans un cas, un broncho-spasme transitoire, et dans l'autre, une obstruction bronchique importante nécessitant l'intubation d'urgence à deux reprises: ceci nous a amené à éviter l'emploi du Valium chez ce groupe de patientes. L'anesthésie a été maintenue avec de l'halothane et de l'oxygène sans aucun incident fâcheux.

L'opération elle-même a consisté en une thyroïdectomie subtotale conventionnelle et s'est déroulée de façon normale. En général le chirurgien a noté que les glandes étaient fermes, et n'étaient pas plus vascularisées que les glandes préparées de façon conventionnelle.

L'examen histopathologique a montré les aspects connus de l'hyperplasie des vésicules thyroïdiennes, mais il n'y avait pas d'infiltration appréciable du parenchyme par des lymphocytes et des plasmocytes comme on a l'habitude de les rencontrer dans les goitres traités de façon classique.

Propranolol a été administré par la voie intraveineuse immédiatement après l'opération à un dosage de 1 mg/h pour les premières 12 heures ou du moins jusqu'à ce que la patiente soit capable d'utiliser la voie orale, la posologie étant la même que la période pré-opératoire. Durant cette période du traitement, une surveillance attentive des signes vitaux a été faite par monitorat continu. A partir du troisième ou quatrième jour, une diminution progressive de la quantité de propranolol a pu être faite, suivie d'un arrêt complet après cinq ou sept jours.

Résultats

Durant la période post-opératoire, l'équilibre métabolique s'est maintenu chez toutes les patientes, comme l'indiquaient le pouls, la respiration, la tension artérielle et la température. Il s'agissait donc de déterminer si l'intervention chirurgicale avait modifié vraiment la fonction thyroïdienne étant donné que cette fonction n'avait pas été affectée dans la période pré-opératoire, le propranolol n'agissant pas à ce niveau, du moins dans l'état actuel des connaissances.

A cause de l'effet anti-adrénergique du propranolol, nous nous sommes intéressés particulièrement aux modifications électrocardiographiques que pourrait provoquer l'utilisation de ce médicament. Durant la période pré-opératoire alors qu'un fort dosage de propranolol était nécessaire, aucune modification n'a été notée à l'électrocardiogramme. Cependant, des inversions des ondes T et des changements non spécifiques sont apparus au troisième jour post-opératoire chez la majorité des patientes, sans qu'on puisse mettre en évidence des symptômes ou signes évidents d'ischémie myocardique. Cependant, deux jours après avoir cessé le propranolol, les ondes T sont disparues de même que les changements non spécifiques. Il nous est impossible actuellement d'expliquer de telles modifications de l'électrocardiogramme. De plus, la vectocardiographie faite, avant, durant et après l'administration de propranolol a donné des résultats tout à fait normaux.

La captation de l'iode radioactif a atteint les limites de la normale après sept jours chez sept patientes soumises à cet examen. De même, la thyroxine sérique indique clairement que la fonction thyroïdienne était devenue presque normale au quatrième jour, et que toutes les patientes étaient euthyroïdiennes au septième jour.

Le résultat est demeuré presque constant jusqu'à ce jour puisqu'après une période d'observation de 10.6 mois en moyenne l'état clinique et les épreuves de fonction thyroïdienne sont demeurées inchangées. Deux patientes présentent des signes cliniques et biologiques d'hypothyroïdie, nécessitant l'emploi d'extraits thyroïdiens (tableau 1).

Discussion

A la suite de cette étude, quelques points importants doivent être soulignés dans l'évaluation de cette méthode de traitement.

En premier lieu, le propranolol est un médicament sûr, à l'action rapide et qui ne donne aucun effet secondaire. Au contraire des antithyroïdiens, son action est transi-

toire, d'où la nécessité de continuer l'administration du médicament durant la période post-opératoire soit cinq à sept jours, alors que le patient devient euthyroïdien. Cette période de temps correspond assez exactement à la demie-vie de la thyroxine endogène qui, selon Lee et ses collaborateurs[10] est de 7.2 jours, et d'après Sterling et Chodos,[11] 6.2 jours. Dans notre milieu, la demi-vie de la thyroxine a été établie à 5.3 jours, le calcul étant fait sur ce groupe particulier de malades.

La rapidité d'action de propranolol permettrait de traiter assez rapidement certains patients porteurs d'hyperthyroïdie et présentant des pathologies aiguës, telles qu'un ulcère perforé ou d'autres problèmes chirurgicaux ou médicaux. Cependant, il n'est pas indiqué d'utiliser propranolol en état de grossesse à cause de l'absence de données à ce sujet.

Parmi les avantages les plus importants, notons le raccourcissement marqué de la période pré-opératoire, qui n'a été que de trois à quatre jours chez la plupart des malades, dont plusieurs venaient de régions éloignées du Québec. Cet avantage est qualifié d'assez exceptionnel par le chirurgien et l'endocrinologue habitués à la préparation assez longue que nécessite l'emploi d'antithyroïdiens et d'iode.

Il n'y a pas eu de crise thyroïdienne, mais, connaissant l'efficacité constante du propranolol dans le traitement de cette complication, selon nous, il aurait suffi d'une légère modification du dosage du médicament pour en contrôler les effets.

L'intervention chirurgicale s'est déroulée normalement dans tous les cas, sans que le chirurgien ait noté de difficultés particulières: dans certains cas, l'opération apparaissait même plus facile que dans le cas de patients préparés de façon conventionnelle.

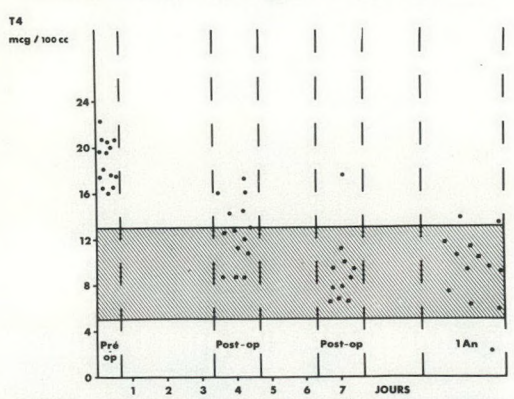
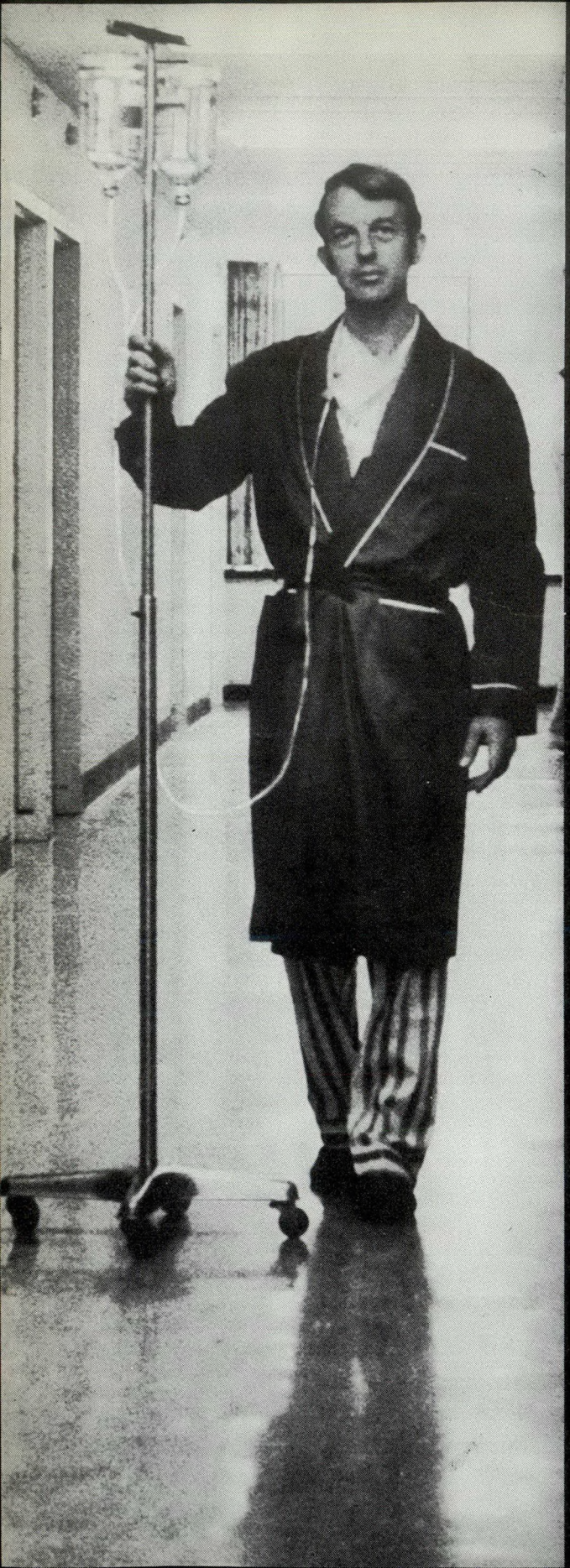


Tableau 1.—Les valeurs de la thyroxine sérique dans la période pré-opératoire et post-opératoire chez les patientes préparées avec propranolol.

Bien qu'on semble d'avis que propranolol n'exerce aucun effet sur la glande thyroïde, certaines études enzymatiques et histochimiques devraient être faites afin de vérifier cette hypothèse: cependant, au point de vue pharmacologique, il semble peu probable que ce médicament ait une action quelconque sur la glande elle-même. De plus, facteur assez rassurant, malgré les modifications électrocardiographiques transitoires notées vers le troisième jour post-opératoire, propranolol ne semble pas avoir affecté l'activité normale du myocarde chez nos patientes, comme l'ont démontré les examens électrocardiographiques faits avant, pendant, et après le traitement chirurgical. Concernant ce point précis, cette tolérance assez particulière qu'ont les patients souffrant d'hyperthyroïdie de pouvoir recevoir d'assez fortes doses de propranolol sans inconvénients notables doit être soulignée; notons cependant que les changements notés à l'électrocardiogramme vers le troisième jour post-opératoire sont survenus au moment où les patients recevaient des doses moins importantes de propranolol. Des modifications analogues d'ordre hémodynamique ont été rapportées chez des patients normaux recevant de faibles doses de propranolol.[12]

Les résultats du traitement chirurgical ont été tout à fait satisfaisants, tant sur le plan clinique que sur le plan biologique. Il semble bien que le pourcentage de patients souffrant d'hypothyroïdie après opération sera à peu près le même que chez les patients préparés de façon conventionnelle.

De cette étude se dégagent plusieurs points démontrant que cette façon de procéder présente certains avantages dont les principaux sont les suivants: le médicament est sûr, a une action rapide, et ne semble pas donner d'effets secondaires; la période pré-opératoire est considérablement raccourcie, permettant à l'intervention chirurgicale de se faire avec sécurité après quatre à cinq jours de préparation; enfin les résultats du traitement chirurgical, chez de tels patients, sont satisfaisants et, jusqu'à présent, comparables aux résultats qu'on peut obte-



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OSMOLALITY OF HYPERALIMENTATION SOLUTION INFUSED INTO THE SUPERIOR VENA CAVA*

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Summary: The solutions for intravenous hyperalimentation must be infused into a large central vein where they are rapidly diluted so that thrombosis will not occur. The rate of this dilution was studied in 12 patients.

The technique commonly used in intravenous hyperalimentation was employed: a 20-cm catheter was threaded via the right subclavian vein to the superior vena cava, leaving 2.5 cm of catheter between the skin and the 5-cm needle. Thirty days later a left subclavian puncture was performed and a catheter inserted in the same way into the superior vena cava. Because the great veins are on the right side of the mediastinum, the right catheter tip was 1.2 to 3.1 cm (mean 2.1) in advance of the left catheter measured radiographically. The solutions were pumped into the left subclavian catheter at a rate of 400 to 500 mg of glucose per minute (glucose:protein hydrolysate ratio of 5:1), and after withdrawing samples, serum osmolalities were measured.

Hyperalimentation solution osmolality ranged from 1,055 to 1,860 mOsm/kg H_2O. Mean osmolality of serum from the right caval catheter was 286 mOsm/kg, from the femoral artery 286 mOsm/kg and from the femoral vein 287 mOsm/kg H_2O. In all serum samples osmolality was in the normal range, and was not significantly higher in samples drawn from the superior vena cava.

Dilution in the superior vena cava of extremely hyperosmolar hyperalimentation solutions, at the rates commonly administered, appears to be immediate.

Résumé: Pour éviter le développement d'une thrombose, on doit perfuser les solutions destinées à l'hyperalimentation par voie intraveineuse dans une grosse veine centrale, où elles se diluent rapidement. La vitesse de cette dilution a été étudiée chez 12 malades.

Nous avons employé la méthode couramment utilisée dans l'hyperalimentation par voie intraveineuse: nous avons introduit un cathéter de 20 cm dans la veine cave supérieure, via la veine sous-clavière droite, en prenant soin de laisser un bout de cathéter entre la peau et l'aiguille de 5 cm. Après 30 jours de perfusion, au moment où on change le cathéter, nous avons ponctionné une veine sous-clavière gauche et, de la même façon, nous avons introduit un cathéter dans la veine cave supérieure. Etant donné que les grandes veines sont situées du côté droit du médiastin, l'extrémité du cathéter droit était en avance de 1.2 à 3.1 cm (moyenne 2.1 cm) sur le cathéter gauche (mesuré radiographiquement). Nous avons pompé les solutions dans le cathéter de la sous-clavière gauche à un débit de 400 à 500 mg de glucose par minute (le rapport glucose/hydrolysat de protéine étant de 5 à 1) et, après avoir prélevé des échantillons, nous avons mesuré l'osmolalité du sérum.

L'osmolalité de la solution d'hyperalimentation a varié de 1,055 à 1,860 mosm/kg d'eau. L'osmolalité sérique moyenne provenant du cathéter droit de la veine cave était de 286 mosm/kg, de l'artère fémorale de 286 mosm/kg et de la veine fémorale de 287 mosm/kg d'eau. Dans tous les échantillons de sérum, l'osmolalité est demeurée dans les limites normales, et n'était pas nettement plus élevée dans les échantillons prélevés directement dans la veine cave supérieure.

Par ailleurs, la dilution dans la veine cave supérieure de solutions d'hyperalimentation très fortement hyperosmolaires, est immédiate aux débits couramment utilisés.

OSMOLALITY is a measure of osmotic pressure which depends on the number of particles (ions and undissociated molecules) in solution, and is expressed as mOsm/kg H_2O.[1] Normal serum osmolality is 270 to 300 mOsm/kg H_2O. In intravenous hyperalimentation, markedly hypertonic solutions of glucose and amino acids are infused.[2, 3] It is known that even a twice osmolar solution when introduced into a peripheral vein will eventually cause phlebitis. To avoid phlebothrombosis the highly concentrated solutions used in hyperalimentation are dripped into a large-diameter central vein, such as the superior vena cava, thus favouring their rapid dilution. Passage of viscid

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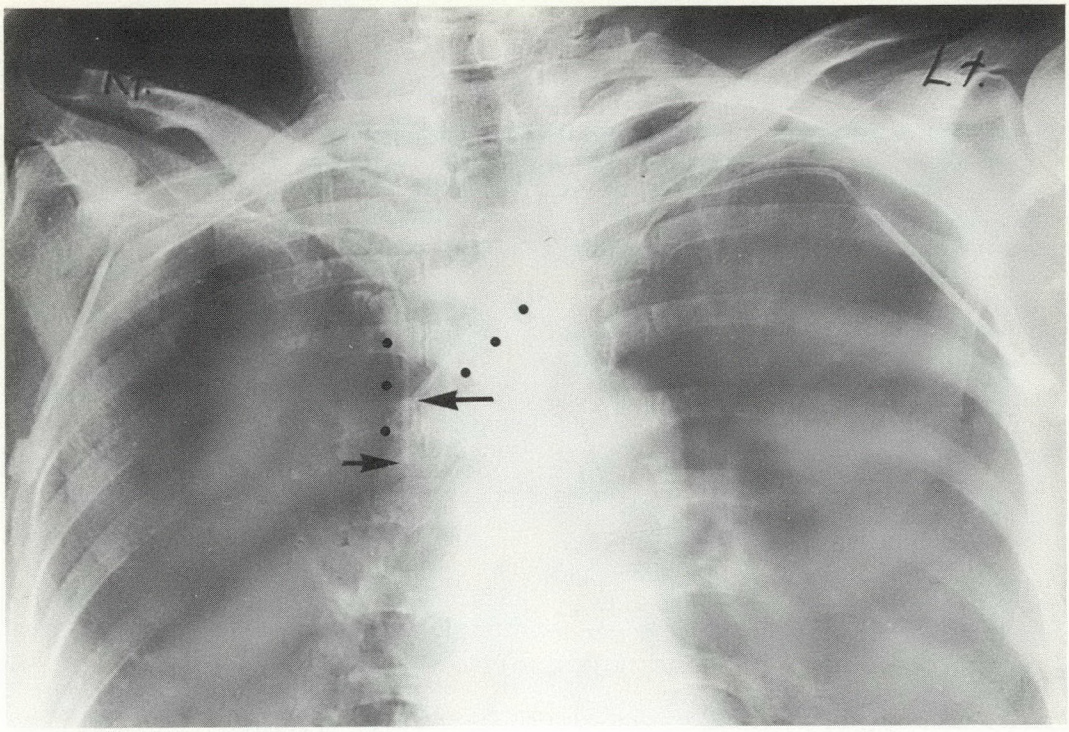

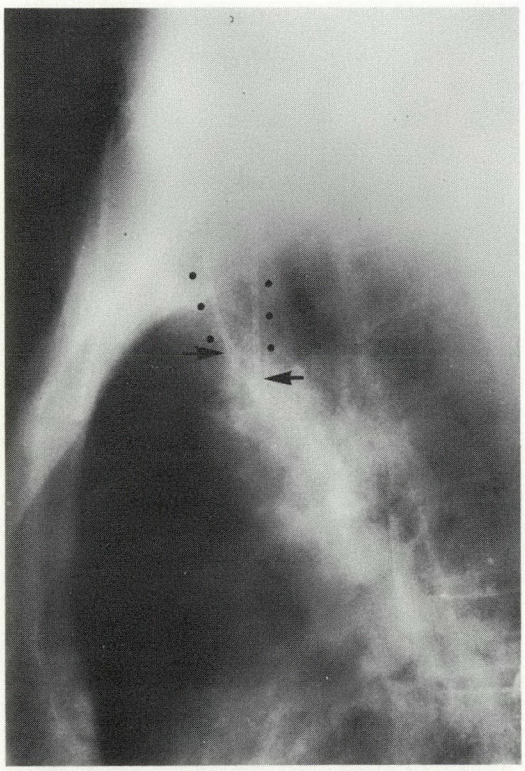

Fig. 1.—(a) Anteroposterior and (b) lateral radiographs showing the relative catheter positions.

solution through the pulmonary circulation could have deleterious effects. Furthermore, accumulation of the hyperosmotic solution could lead to intracellular dehydration and hyperosmotic non-ketotic coma.[4] The rapidity of dilution of the hyperosmotic hyperalimentation solution in the superior vena cava was studied in 12 patients.

METHOD

The technique commonly used in intravenous hyperalimentation was employed:[2] using aseptic precautions, a 20-cm polyvinyl catheter was inserted via the right subclavian vein into the superior vena cava. A 2.5-cm length of the catheter was left between the 5-cm needle and the skin. After 30 days of hyperalimentation via the first catheter (the length of time we generally leave catheters *in situ),* a second 20-cm catheter was threaded down the left subclavian vein into the superior vena cava, and again 2.5 cm of catheter was left between the needle and the skin. The positions of the catheter tips were confirmed by radiography, and the studies were carried out before the right catheter was removed.

As the superior vena cava lies on the right side of the mediastinum, the right catheter tip lies 2 to 3 cm in advance of the left catheter if positioned correctly. Hyperalimentation solution of known osmolality was pumped at a constant rate (400 to 500 mg of dextrose per minute, with a dextrose: amino acid ratio of 5:1) through the left catheter, while a sample of blood distal to the left catheter tip was withdrawn through the right catheter. The osmolality was determined of this sample, and of peripheral venous and arterial samples obtained from the femoral vein and artery respectively. Measurements were based on the depression of freezing point of the water in the patient's serum below that of distilled water using the model 66-31 LAS advanced osmometer.

The distance between the proximal and distal catheter tips was measured directly from the chest radiographs (anteroposterior and lateral views, Fig. 1), and the percentage magnification was calculated from the actual 20-cm length of the catheter compared with the x-ray length (Table I).

Results

The mean osmolality of the hyperalimentation solution was 1,361 mOsm/kg H_2O, more than four times the osmolality of normal serum. The mean distance between the two catheter tips was 2.1 cm and the mean osmolality in the superior vena cava at the distal catheter tip was 286 mOsm/kg H_2O. The mean peripheral arterial and venous osmolalities were 286 and 287 mOsm/kg H_2O respectively. In all patients the serum osmolality in the superior vena cava and the peripheral vessels was within the normal range.

Comment

In patients who are being adequately hydrated and who are non- or controlled diabetics, the nutrients infused are metabolized peripherally, so that serum concentrations do not rise and hyperosmolality does not develop. Moreover, the dilution of the infusion in the patients whom we studied appeared to be extremely rapid.

Summary

A study was conducted in 12 patients to ascertain how rapidly the markedly hyperosmotic solutions used in intravenous hyperalimentation, at the rates commonly administered, are diluted in the superior vena cava. In all cases dilution appeared to be immediate.

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TABLE I.—Osmolality Measurements in Patients on Hyperalimentation

Patient no.	*Osmolality of IVH solution (mOsm/kg H_2O)*	*Serum osmolality (mOsm/kg H_2O)*			*Distance between catheter tips on radiographs (cm)*	*Magnification (%)*	*Corrected distance between catheter tips (cm)*
		Superior vena cava	*Peripheral vein*	*Peripheral artery*			
1	1,370	287	290	287	2.7	10.3	2.4
2	1,292	297	298	297	1.9	8.8	1.7
3	1,517	294	293	294	3.3	11.7	2.9
4	1,135	286	287	288	3.4	10.3	3.1
5	1,148	291	291	291	1.6	8.8	1.5
6	1,671	283	286	280	2.4	14.7	2.0
7	1,055	297	295	295	1.3	10.3	1.2
8	1,200	268	275	273	1.4	13.2	1.2
9	1,860	270	268	268	3.2	3.3	3.1
10	1,272	276	278	277	2.3	9.8	2.1
11	1,487	290	290	290	3.0	12.0	2.6
12	1,324	292	293	291	1.9	9.1	1.7
Mean values	1,361	286	287	286	2.4	10.2	2.1

CANCER RISK IN ULCERATIVE COLITIS: ITS INDEPENDENCE OF LUMINAL FACTORS

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Summary: Two patients developed cancer of the rectum several years after an ileostomy had been performed because of ulcerative colitis. Bypass of the large bowel therefore does not reduce the significant risk of malignant change incurred by patients suffering from ulcerative colitis.

Résumé: Deux malades ont présenté un cancer rectal plusieurs années après avoir subi une iléostomie pratiquée pour colite ulcéreuse. Il s'ensuit que le court-circuitage du gros intestin ne réduit pas nécessairement le risque incontestable de transformation maligne qu'encourent les malades atteints de colite ulcéreuse.

THE risk of cancer of the large intestine is markedly increased in patients with ulcerative colitis, whether they contract their disease during adulthood[1] or during childhood.[2-4]

Once ulcerative colitis has developed the colonic mucosa remains permanently abnormal in most patients, at least if continuity of the bowel is maintained.[5] Colectomy with anastomosis of the ileum to the diseased rectum does not protect against cancer risk[6] but we did not know whether bypass of the diseased bowel would protect against it. This question is relevant because intraluminal factors, particularly those of a dietary nature, have been implicated in the genesis of cancer of the colon and rectum.[7]

Cancer of the rectum developed in two patients a number of years after colectomy and ileostomy had been performed for ulcerative colitis.

CASE REPORTS

Case 1.—A 45-year-old woman sought help at the emergency department for a perineal mass.

A diagnosis of ulcerative colitis had been made when she was 20 years old. The onset was acute and she had had two other acute episodes at the ages of 28 and 39. Ileostomy without colectomy was carried out during that third attack and was followed four months later by subtotal colectomy. Abdominoperineal resection was performed when she was 43 years old for persistent rectal bleeding. After the last operation she suffered from intermittent perineal discharges for six months but was thereafter asymptomatic.

Two weeks before her admission to the emergency department she noted a sensation of a perineal mass with progressive, localized pain. At examination, a small mass, dark and tender, could be seen protruding at the site of the perineal incision. During vaginal examination, a 3 x 7-cm cystic mass was palpable at the former location of the rectum. Colourless mucoid fluid (300 ml) was drained from the cyst via the perineum. A biopsy was taken of the cyst wall which showed mucus-secreting cells. When the cyst was completely resected a well-differentiated adenocarcinoma was demonstrated, originating in a portion of residual rectal wall (Fig. 1). A review of the original

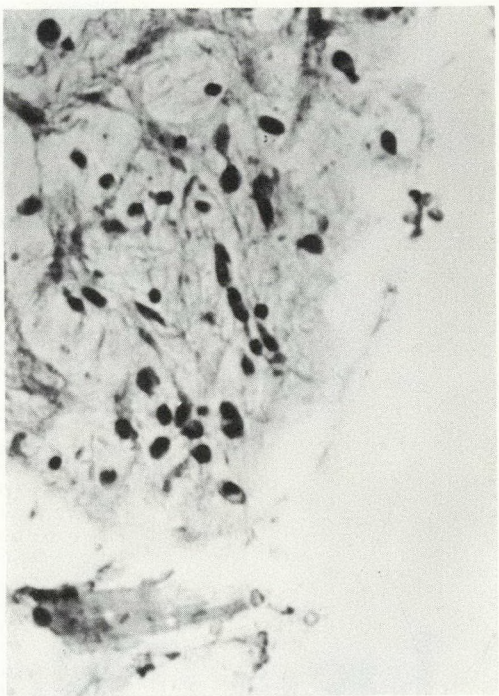

Fig. 1.—Mucus-producing adenocarcinoma.

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specimens of colon and rectum failed to demonstrate any malignant changes.

Case 2.—A patient we have kept under surveillance since the onset of ulcerative colitis during childhood[2] developed cancer of the large intestine[8] originating in the rectum. Forty-four years earlier, at the age of 11 years, she had had a diverting ileostomy and had refused further operation. Drainage of recent onset from the bypassed intestine led to a proctocolectomy, and a grade I mucoid adenocarcinoma was found in the rectum.

Discussion

These case histories indicate that bypass of the colon in patients with ulcerative colitis will not prevent the genesis of cancer of the large bowel. Few physicians will leave permanently bypassed a rectal stump, and the development of a cancer in residual rectal mucosa is, of course, the result of a technical error. Hence it is difficult to quantify the risk of cancer in a bypassed segment of large intestine involved by colitis. This brief report serves only to indicate that if operation is performed to protect the patient with ulcerative colitis against cancer risk, proctocolectomy should be done. It appears also that cancer may develop as a complication of ulcerative colitis even if the fecal stream has been diverted and therefore that luminal factors are not predominant elements in the genesis of these cancers.

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PREDUODENAL PORTAL VEIN: A SIGNIFICANT ENTITY? REPORT OF TWO CASES AND REVIEW OF THE LITERATURE*

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Summary: A preduodenal position of the portal vein is rare. To the 39 cases already mentioned in the literature, we add this report of two cases in which the condition was diagnosed during surgical exploration for neonatal duodenal obstruction. A short explanation of the embryology of the malformation is presented. The habitual presence of associated anomalies is emphasized. We believe these, and not the preduodenal portal vein, produce the clinical picture of duodenal obstruction and these lead to the discovery of the abnormal position of the vessel.

Résumé: La situation préduodénale de la veine porte est rare. La littérature comporte seulement 39 cas. Les auteurs rapportent deux observations personnelles dont la malformation a été découverte lors de l'exploration chirurgicale pour occlusion duodénale néonatale. Le rappel embryologique permet d'analyser les différentes dispositions anormales de la veine porte. Les malformations associées fréquemment présentes sont, selon les auteurs, la cause d'obstruction duodénale dans la majorité des cas.

VARIATIONS in the tributaries of the portal vein are numerous,[1, 2] but the course of the portal vein itself, behind the duodenum, and its relationship to the porta hepatis are quite constant. In a review of the world literature we have been able to find only 39 reported cases of an anomalous position of the portal vein.

The first description of a preduodenal portal vein was published by Begg[3] in 1912, in a 10-mm pig embryo. Nine years later Knight[4] found this anomaly in a human at autopsy and pointed out its surgical implication. In 1926 Schnitzler[5] was the first to operate successfully on such a case, in an adult.

Within the past few years we have had the opportunity to treat two newborn infants with this malformation. In both instances the malformation was discovered during surgical exploration for duodenal obstruction. The experience gained from our cases and a critical review of the 39 published cases make us question whether the easy explanation, that symptoms of duodenal obstruction are attributable to a preduodenal portal vein, is the correct one. The symptoms may be caused by other associated anomalies.

CASE REPORTS

Case 1.—B. P., born on June 22, 1968, was transferred to Ste Justine Hospital for Children, Montreal, 15 hours after birth because of bilious vomiting. The family history was non-contributory and there had been no polyhydramnios during the pregnancy.

The baby was slightly hypotonic and dehydrated on admission. The abdomen was soft and scaphoid, with no hepatosplenomegaly or any adventitious mass. Bowel sounds were absent. No meconium had been passed but the anus was patent.

A plain radiograph of the abdomen with the child in the upright position showed air in the stomach and as far distal as the second portion of the duodenum but none beyond. A barium enema confirmed the normal position of the colon.

After rehydration a laparotomy was performed on June 24 when a preduodenal portal vein was found associated with complete obstruction of the intestinal lumen at the junction of the second and third portions of the duodenum. As it was impossible to pass a Levin tube or even inject air beyond that level, it was concluded that atresia was complete, and enterotomy to demonstrate a diaphragm was not performed. Side-to-side duodenoduodenal

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anastomosis was carried out. The postoperative course was uneventful.

Case 2.—R. C., born on June 26, 1972, was admitted on the sixth day of life to Ste Justine Hospital because of persistent emesis of green material since birth. There was no pertinent family history.

The general clinical picture was one of high intestinal obstruction. Plain radiograph of the abdomen with the infant in the upright position showed air-fluid levels in the stomach and first portion of the duodenum. Air was also seen in the small bowel, especially on the left side of the abdomen (Fig. 1), suggesting an incomplete obstruction at the second portion of the duodenum. An upper gastrointestinal series done through a gastric tube opacified a normal stomach and dilated first and second portions of the duodenum. A small amount of barium could be seen trickling along the third and fourth portions of the duodenum (Fig. 2).

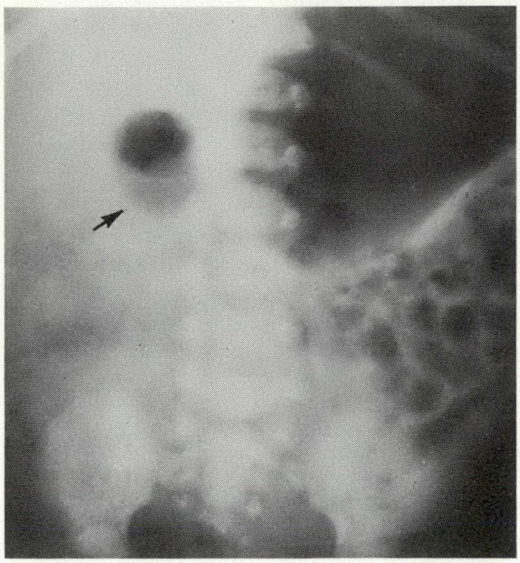

Fig. 1.—Case 2. Abdominal film on admission demonstrating the presence of an air-fluid level in the first portion of the duodenum and air in the small bowel on the left side of the abdomen.

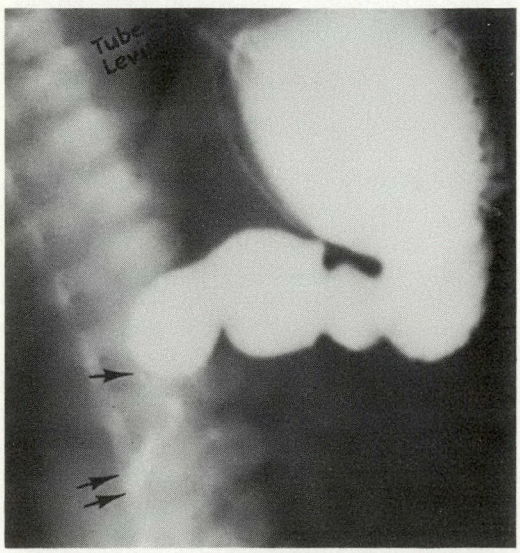

Fig. 2.—Case 2. Dilated first and second portions of the duodenum and a small amount of contrast material in the third and fourth duodenal portions following the administration of barium.

The baby was operated upon the next day. A malrotation was found and the Ladd procedure performed. Then, through a Stamm gastrostomy, a size 10 French Foley catheter was introduced into the duodenum but could not be pushed beyond the junction of the first and second portions, where there were still some bands holding the duodenum to the gallbladder. While freeing those bands we came upon a large vessel lying in front of the duodenum at the level where the Foley catheter was arrested. Through a duodenotomy, and with the help of the Foley catheter, we were able to demonstrate an intraluminal diaphragm (windsock type) with a 1- to 2-mm aperture located eccentrically. The ampulla of Vater was located within the wall of the diaphragm posteriorly (Fig. 3). The diaphragm was excised except for its posterior portion. After closure of the duodenotomy the Foley catheter

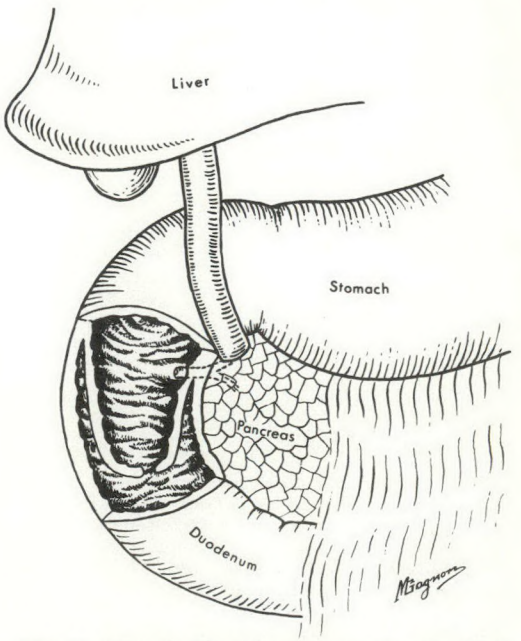

Fig. 3.—Case 2. Drawing representing the findings at operation.

could be easily inserted to the fourth jejunal loop; even with its balloon inflated it could be withdrawn without hindrance. A gastrostomy tube was left in the stomach and the wound closed. The postoperative course was smooth.

Embryology

The embryological development of the portal vein in man provides a satisfactory explanation for its preduodenal position.[6-8] At the 4-mm stage of embryonic life the two parallel vitelline veins of the yolk sac, which drain the venous blood from the primitive gut, are connected by three anastomotic branches (Fig. 4): (1) the superior anastomosis which lies within the liver; (2) the middle anastomosis which is subhepatic and retroduodenal; and (3) the inferior anastomosis which is preduodenal and lies below the entrance of the common bile duct into the duodenum.

Parts of this vascular arrangement become atrophic and at the 9-mm stage of embryonic life the superior and inferior anastomoses as well as the superior part of the left vitelline vein and the inferior part of the right vitelline vein normally disappear. The middle anastomosis persists and becomes the origin of the portal vein which passes in the form of an "S" behind the duodenum.

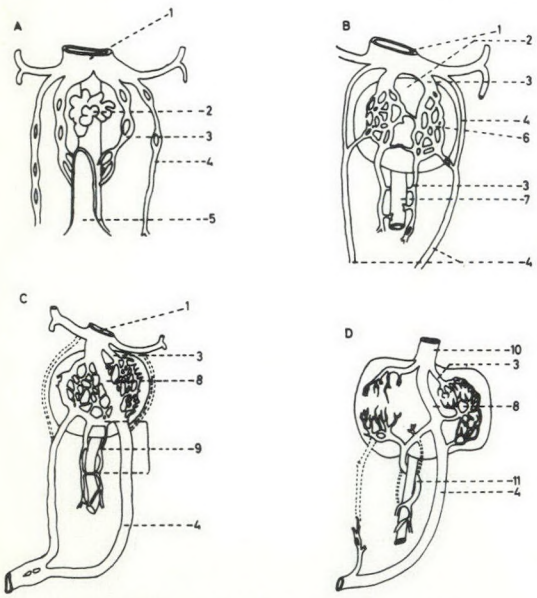

Fig. 4.—Embryological development of the portal vein (after Patten[7]): (A) 4-week-old embryo, (B) 5-week-old embryo, (C) 6-week-old embryo and (D) 7-week-old embryo. 1 = sinus venosus, 2 = liver bud, 3 = left vitelline vein, 4 = left umbilical vein, 5 = vitelline duct, 6 = hepatic capillary plexus, 7 = intestine, 8 = ductus venosus, 9 = superior, middle and inferior vitellovitelline anastomoses, 10 = inferior vena cava, 11 = portal vein.

If the middle retroduodenal anastomosis atrophies and the inferior preduodenal anastomosis remains patent, the result is a preduodenal location of the portal vein. Several other abnormal patterns may develop but this one is the most common.

It is also important to realize that anatomical abnormalities of the portal vein can also be caused by an embryological maldevelopment of the gut. Malrotations of the foregut, for example, can result in an inversion of varying degree. Thus, a situs inversus of the stomach and duodenum can lead to a preduodenal location of the portal vein, although the embryological development of the vessel is normal.[9]

Discussion

Of the 39 cases of preduodenal portal vein that we found in the literature and the two cases reported above (Table I),[4, 5, 8-33] 34 (83%) had other associated malformations, often multiple (Table II).

The most frequent of these were intestinal malrotation (30 cases) and situs inversus (12 cases). Next in order were anomalies of the duodenum: stenosis in one, atresia in three and intrinsic diaphragm in seven cases. It is well known that malrotation and intrinsic duodenal obstruction are frequently associated; this was so in nine cases (30%).

If one considers that anomalies of the pancreas (10 cases), biliary atresia (four cases), duodenal malformations (11 cases) and congenital duodenal bands (eight cases) also can be found with a preduodenal portal vein, it becomes evident that the embryological defect involves many neighbouring structures located in an area of "great embryological activity".

From a pathophysiological point of view, the preduodenal portal vein is probably the least significant feature of this composite picture. A detailed analysis of these 41 cases has not convinced us that in the anterior position the portal vein can obstruct the duodenum. From a theoretical standpoint

it seems difficult to believe that a low venous pressure within a thin-walled vessel can cause such an obstruction. It is more likely that the reverse is true, that the duodenum obstructs the portal vein and creates portal hypertension. Yet this has never been reported. Furthermore, in most cases (83%) the associated malformations, e.g. duodenal bands, annular pancreas and malrotation, can adequately explain the symptoms. Finally, many of the above cases were treated by performing a short-circuiting anastomosis around the portal vein without making any real attempt to exclude intrinsic stenosis of the duodenum. The fact that many cases of preduodenal portal vein have been reported in adults does not rule out an intrinsic diaphragm as the real cause of ob-

TABLE II.—MALFORMATIONS ASSOCIATED WITH 33 CASES OF PREDUODENAL PORTAL VEIN

Intestinal malrotation, non-rotation and incomplete fixation	30
Abdominal situs inversus, partial or complete	12
Duodenal malformations:	11
stenosis 1	
diaphragm 7	
atresia 3	
Pancreatic malformations	10
Cardiovascular malformations and dextrocardia	9
Congenital periduodenal bands	8
Splenic anomalies	6
Biliary atresia	4
Sacral agenesis	1
Down's syndrome	1
Total	92

TABLE I.—REPORTED CASES OF PREDUODENAL PORTAL VEIN

Author	*Age*	*Sex*	*Duodenal obstruction due to:* *Portal vein*	*Other causes*
Knight 1921[4]	60 yrs	M	No	No
Pernkopf 1926[10]	—	M	No	No
	Newborn	M	No	No
	Child	M	No	No
Schnitzler 1926[5]	41 yrs	M	Yes	No
Pernkopf 1928[8]	19 yrs	M	No	No
Lehmann 1931[11]	—	M	Yes	No
Pernkopf 1932[12]	Adult	—	No	No
Stengel 1934[13]	9 mths	F	No	No
	50 yrs	F	No	No
Ravitch and Woods 1950[14]	8 days	M	No	Yes
Grob 1953[15]	7 days	M	No	No
Snavely and Breakell 1954[16]	24 yrs	F	No	No
Roviralta 1958[17]	3 days	F	No	Yes
Bernard, Perry and Walker 1959[18]	48 yrs	F	Yes	No
Block and Zikria 1961[19]	10 yrs	F	Yes	Yes
Boles and Smith 1961[20]	3 mths	M	No	No
	3 days	—	Yes	Yes
	5 days	—	No	Yes
	7 days	—	No	Yes
Debray *et al* 1962[21]	65 yrs	M	No	No
Majewski 1962[22]	57 yrs	F	No	Yes
Renner and Child 1963[23]	7 wks	M	No	No
Moreaux, Pette and Chapuis 1965[24]	27 yrs	F	No	No
Kopecký and Halatová 1968[25]	7 days	F	Yes	No
Kakkar and Tompkin 1968[26]	29 yrs	M	Yes	No
Laube and Weise 1969[27]	48 yrs	F	No	No
Horovitz and Riesenfeld 1971[28]	3 days	F	Yes	No
Mooney 1971[29]	3 days	F	Yes	Yes
Braun and Cuendet 1971[9]	8 days	M	No	Yes
	4 days	M	No	Yes
Johnson 1971[30]	2 mths	F	No	No
	2 days	F	No	Yes
Welte and Gharib 1972[31]	Newborn	F	Yes	No
	11 days	M	No	Yes
Bower and Ternberg 1972[32]	3 yrs	F	Yes	No
	4 days	F	No	Yes
	5 days	F	Yes	No
Lamesch, Eydt and Steinmetz 1972[33]	3 yrs	F	Yes	No
This report	1 day	M	No	Yes
	6 days	M	No	Yes

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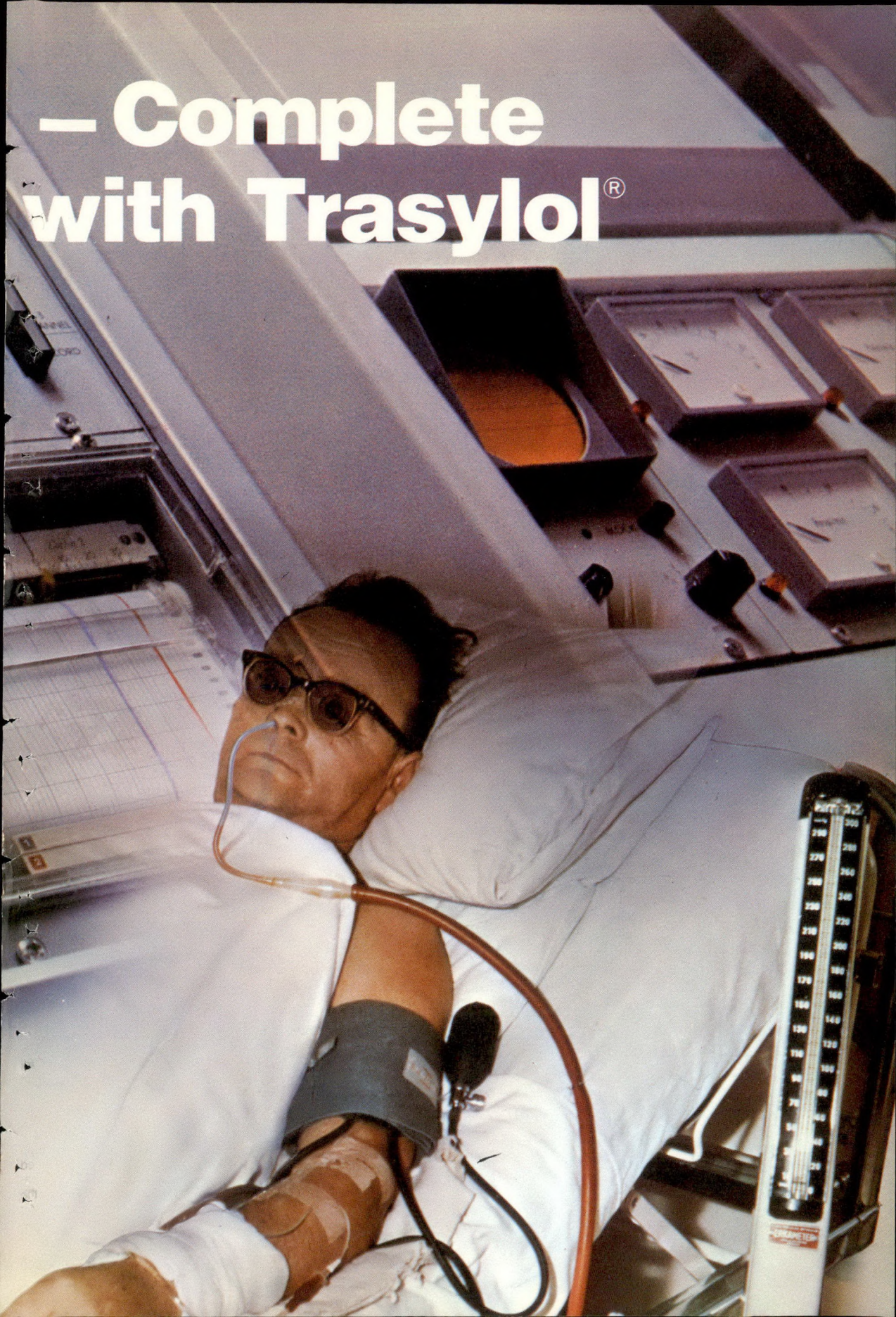
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struction; Smiley, Perry and McClelland[34] reviewed 20 cases of congenital diaphragm in adults and state that 29% of the patients first developed symptoms after the age of 24 years.

In conclusion, we believe that a preduodenal portal vein is probably never responsible for duodenal obstruction and when it is found in association with some degree of this condition the duodenum should be explored to discover whether a diaphragm is present. This can be done easily by inserting a Foley catheter into the duodenum, inflating the balloon and then withdrawing it, as suggested by Richardson and Martin.[35] If such a diaphragm exists, its excision through a duodenotomy should correct the abnormality.

The main surgical implication of a preduodenal portal vein is the recognition of this anomaly and the avoidance of injury during operations on the biliary tract and the duodenum.[27]

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SURGICAL ASPECTS OF AMEBIASIS*

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Summary: Forms of amebiasis likely to be encountered by the surgeon are discussed by reference to illustrative case reports. The clinical picture may be one of intestinal, hepatic or pleuropulmonary disease. It is desirable that surgical procedures should be preceded by a course of medical treatment. In cases where the diagnosis of amebiasis has been unsuspected before operation, medical treatment should be instituted afterwards without delay.

Résumé: Les diverses formes d'amibiase que le chirurgien est susceptible de rencontrer sont présentées par des rapports cliniques typiques. Le tableau clinique peut comporter des lésions intestinales, hépatiques ou pleuropulmonaires. Il est souhaitable que l'intervention chirurgicale soit précédée d'un traitement médical mais, dans les cas où l'infection a été méconnue avant l'opération, il importe d'entreprendre un traitement médical sans délai tout de suite après l'opération.

AMEBIASIS is endemic in many parts of the world, particularly in certain parts of Africa, Asia and Central and South America, but it occurs also in temperate climates.

Amebiasis can be of particular interest to the surgeon. Its varied modes of presentation often make the diagnosis difficult. Moreover, complications that require surgical treatment develop in an estimated 0.5% of dysenteric patients,[1] and although this is a small fraction of the total amebic morbidity, the life-threatening potential of these cases lends them special importance.[2]

By means of illustrative cases we will endeavour to answer several questions in this paper. When should the surgeon expect amebiasis? How may he make the diagnosis? What should he do if the diagnosis is only made at operation? What is the current medical regimen?

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CASE MATERIAL

From 1966 to 1972 *Entamoeba histolytica* infestation was diagnosed by the University Clinic for Tropical and Parasitic Diseases, Toronto, in over 900 patients. Many of these patients were carriers without signs of active infection. Typical case reports are supplied below.

CASE REPORTS

Case 1.—L. O., a 55-year-old man from northern Ontario, presented with right-sided abdominal pain accompanied by nausea, vomiting and constipation. He had never been outside Ontario and previously had been an institutional psychiatric patient. A subhepatic abscess developed which was drained through a subcostal incision of 1,200 ml of purulent material from which a Proteus species was cultured. Continuous drainage of pus from the incision followed despite antibiotic treatment and fistulas developed between the abscess cavity, the liver and the transverse colon. When transferred to the Toronto General Hospital six months after the initial subcostal incision, the drainage was similar to anchovy sauce. *Entamoeba histolytica* was recovered from the fistula tract. The patient was treated with dehydroemetine and carbarsone, and within three weeks drainage had completely subsided and the fistula had closed. No further surgical treatment was required.

Case 2.—D. H., a 36-year-old man from Toronto, developed repeated respiratory infections accompanied by fever and diarrhea. He had travelled in Colorado, Nevada, Ontario and Michigan and experienced some fatigue following this trip. He suffered from chills, malaise and fever. A liver scan revealed a large cold area over the superior aspect of the right lobe of the liver. At laparotomy a liver abscess was drained of whitish-yellow purulent material which was sterile on routine culture. The pus was also negative for *Entamoeba histolytica*. The abscess cavity was irrigated daily and the patient's condition improved. Sudden onset of chest pain and fever resulted in two further hospital admissions during which pulmonary scans were thought to be consistent with the presence of pul-

monary emboli. Hemoptysis occurred on several occasions. Treatment with anticoagulants and antibiotics produced some clinical improvement.

Six months after the initial illness the patient again became ill with recurrent cough and his weight fell by 35 lbs. Diagnostic investigations included angiography, esophageal motility studies, bronchoscopy and mediastinoscopy. Examination of the stool revealed *Entamoeba histolytica* and hemagglutination tests for the parasite were highly positive. Treatment with dehydroemetine and carbarsone resulted in rapid symptomatic improvement with resolution of the cold area previously observed on the liver scan and improvement in the chest radiograph within two weeks.

Case 3.—J. D., a 68-year-old man, presented with diarrhea, abdominal pain and a 70-lb weight loss a few months after a world tour which included Europe, India, Singapore and Thailand. On examination a rectal mass could be felt, biopsy from which showed chronic inflammation without evidence of carcinoma. A rectal smear showed cysts of *Entamoeba histolytica* and a diagnosis of rectal ameboma was made. Treatment with dehydroemetine and carbarsone cleared the infestation, and the mass shrank to one-third its original size but did not disappear completely. A repeat biopsy was then carried out which revealed adenocarcinoma.

Case 4.—H. G., a 51-year-old war veteran, contracted amebiasis in 1948 in Korea. Despite some residual diarrhea at the time of discharge from the service he was told that he was cured. He remained well until 1971 when, in association with some weight loss and malaise, he developed an acute abdomen. A diagnosis of perforated appendix was made and at laparotomy an abscess was discovered in the mesentery of the terminal ileum. This abscess drained green, odourless fluid. Postoperatively the patient developed a fistula from the sigmoid colon to the small bowel and cecum. An amebic abscess was suspected and treatment with emetine and chloroquine was instituted. A further drainage procedure was carried out and at that time the diagnosis was established on histological examination of tissue sections (Fig. 1). Further medical treatment was followed by radical excision of the fistulas and defunctioning sigmoid colostomy. The colostomy was closed at a later date. The patient remains well and free from disease.

In contrast to Cases 1 and 2, two cases of liver abscess resolved on medical therapy alone without surgical intervention as demonstrated by changes in liver scans (Figs. 2 and 3). One of these is described below.

Case 5.—T. G., a 60-year-old man from southern Ontario, suffered from diarrhea while travelling through Europe. This was effectively treated with a kaolin-pectin mixture. He continued to Australia via Japan, Hong Kong, Bangkok and Singapore. In Australia he had a recurrence of the diarrhea followed a few weeks later by anorexia, fever and right upper quadrant pain. Amebic liver abscess was diagnosed and a course of metronidazole (Flagyl) provided symptomatic improvement. On returning to Ontario he experienced further night sweats, fever and anorexia. On examination dullness and rales were present at the right lung base. The liver was markedly enlarged and the scan showed multiple filling defects. A diagnosis of amebiasis was confirmed by a strongly positive latex test and the presence of cysts of *Entamoeba histolytica* in the stool concentrations. Repeated courses of treatment with dehydroemetine and carbarsone resulted in symptomatic enduring relief with gradual diminution in the size of the filling defect on the scan.

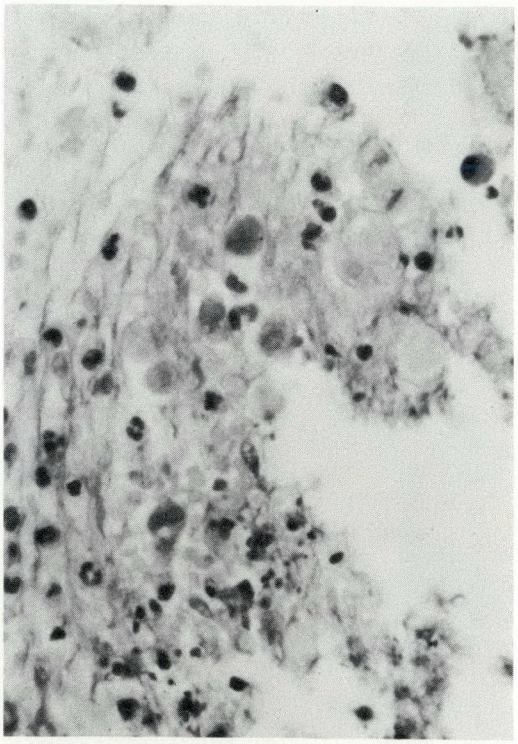

Fig. 1.—Case 4. Multiple cysts of *Entamoeba histolytica* in tissue excised at operation (x 25).

Discussion

The diagnosis of amebiasis depends on a high index of suspicion. A history of travel through endemic areas with subsequent onset of diarrhea is suggestive. Within North America the incidence of the carrier state is much higher in areas where hygiene and waste-disposal methods are not of high standard. Certain Indian reservations and mental institutions have a high prevalence of endemic carriers.

Modes of Presentation

The clinical pictures compatible with the diagnosis may be divided into intestinal and extraintestinal presentations. This classification is useful in determining what diagnostic tests and mode of therapy are appropriate.

Diarrhea.—Patients with amebiasis may be asymptomatic or suffer from mild fulminant diarrhea. Such presenting symptoms are less likely to come to the attention of the surgeon.

Peritonitis.—Marked peritonitis may accompany amebic dysentery even in the absence of perforation of the bowel. In these circumstances laparotomy is generally contraindicated. However, acute peritonitis may occur in the absence of diarrhea and be the result of bowel perforation. Laparotomy and fecal diversion are then indicated after commencement of specific anti-amebic therapy.

Appendicitis.—Amebic typhlitis and amebic appendicitis are not uncommon. Appendectomy may be indicated but unless amebicidal therapy is given, the prognosis is much graver than in cases of bacterial appendicitis, owing to suture slough and resultant peritonitis and fistula formation.

Ameboma.—This development, as in Case 3, is a relatively uncommon occurrence. Radke[3] collected 78 cases and reported on 41 others. He found the most common site to be in the rectum or cecum. The most common complication of ameboma is intermittent or complete obstruction. The possibility that this lesion may be mistaken for adenocarcinoma and be attacked surgically before the start of anti-amebic

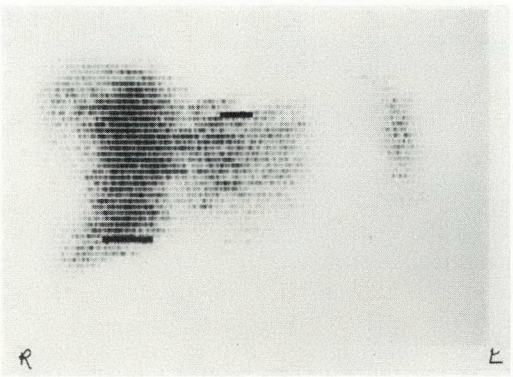

Fig. 2.—(a) Anteroposterior and (b) lateral liver scans before therapy.

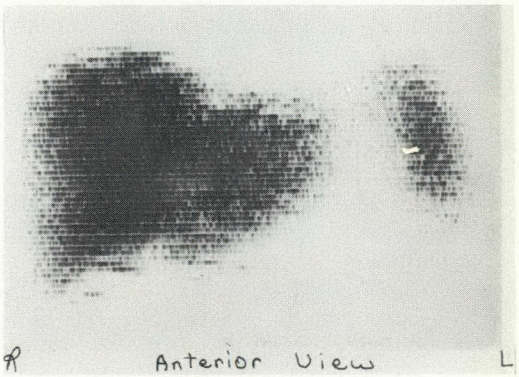

Fig. 3.—(a) Anteroposterior and (b) lateral liver scans after repeated therapy.

therapy may result in peritonitis, perforation, abscess and fistula formation. The coexistence of ameboma with carcinoma may lead to misdiagnosis, but still demands initial anti-amebic therapy before operation.

Cutaneous amebiasis.—This condition is rare and is almost always adjacent to the opening of a fistulous tract. It is characterized by necrosis of skin and subcutaneous tissues caused by a synergistic amebic-bacterial invasion.[4]

Hepatic amebiasis.—Amebic liver abscess is more common in men than in women and in the right lobe of the liver. This is postulated to be a result of a selective portal venous flow by which the drainage from the right colon is primarily to the right hepatic lobe. These abscesses are commonly single and their contents may be creamy white even in the absence of secondary bacterial infection, although the anchovy-paste aspirate is considered pathognomonic. It must be emphasized that, even in proved cases, amebic trophozoites may not be demonstrable in the aspirate yet be observed in the pseudocyst wall. Similarly, cases of liver abscess may no longer show the presence of ameba in the stool. Liver abscesses may rupture into any adjacent cavity—pleural, pericardial or peritoneal. Direct extension to the right pleural cavity and lung occur in 20% of cases. Secondary infection by bacteria of an amebic abscess is not uncommon and should not discourage the clinician from searching for the underlying cause.

Pleuropulmonary amebiasis.—This usually occurs as a direct extension to the right lower chest secondary to amebic liver abscess. It may take the form of pneumonitis, lung abscess, bronchohepatic fistula or empyema. Lung abscesses can be bloodborne, associated even with abscesses in the inferior vena cava.[5]

Diagnostic Methods

Diagnosis requires demonstration of *Entamoeba histolytica* by microscopic examination of stool, pus or scrapings. The parasite may also be cultured on special media. It is not unusual for cysts or trophozoites to be absent from stool or pus, particularly after incomplete or unsuccessful courses of medication. In these cases indirect methods of diagnosis may be used. These include the hemagglutination test, complement fixation, latex, precipitin and fluorescent antibody techniques. These methods are more reliable in the tissue forms of the disease. A cutaneous amebic antigen is presently being used experimentally and may prove valuable in cases where the diagnosis is difficult.

Current Therapy

General.—Amebiasis is an infectious, contagious and notifiable disease. Infection occurs by way of hands soiled with feces, pus, contaminated linen, infected water or food. Isolation of the patient, his linen, excreta and utensils is advisable. Bed rest and a bland low-fat diet are necessary as well as the monitoring of adverse effects of drug therapy.

Intestinal and tissue infection.—In any case of intestinal infection there is no means of excluding definitely the presence of *Entamoeba histolytica* already in the tissues. Therefore we recommend the use of tissue amebicidals followed by surface amebicidals in the full spectrum of cases including those which are asymptomatic. Broad spectrum antibiotics are used in cases where secondary bacterial invasion is suspected or demonstrated.

Preferred Schedule of Treatment in Amebic Dysentery

Dehydroemetine hydrochloride (tissue amebicidal) is given for 10 days. The adult dosage is 60 mg daily (20 mg three times a day intramuscularly or orally).

In cases of increased peristalsis, intestinal hurry and gastrocolic and hepatocolic fistulas, intramuscular administration is recommended as tablets may not be absorbed.

Dehydroemetine has a myocardiotoxic effect which reverses 10 to 14 days after discontinuance of its use. Electrocardiographic changes may be seen (low voltage, T-wave inversion, sinus tachycardia) which demand continuous monitoring and complete bed rest during the treatment.

After completion of the course of dehydroemetine, a course of tissue and surface amebicidals is administered, *viz* carbarsone, 250 mg orally three times a day for seven days or diphetarson, 500 mg orally three times a day for 10 days.

Other schedules of therapy may also be used. Chloroquine combined with carbarsone or diphetarson followed by diiodohydroxyquin is effective.

Metronidazole is widely used for symptomatic suppression. We strongly counsel against reliance upon it as the sole antiamebicidal agent as several cases of liver abscess have been noted after its use.[6]

Tissue manifestations may require two or more complete courses of treatment. Diminution in size of liver abscesses as shown by serial scans may take months, lagging behind completion of treatment.

Recently Tsai[7] reported a series of 2,322 cases of amebic liver abscesses in Taiwan, treated by repeated courses of combination medical therapy. He achieved a very acceptable mortality rate of 21.3% and concluded that aspiration is unnecessary as part of the routine treatment of amebic abscess.

Topical therapy in the form of irrigation of fistulas or abscesses with sterile solutions of Vioform 3% or acriflavine 1% are helpful.

Surgical Procedures

Empyema, perforation, fistulas or large liver abscesses may all necessitate some surgical intervention, but this should be preceded by suitable amebicidal medication.

If the diagnosis is not suspected until the time of operation (e.g. in amebic appendicitis or amebic liver abscess) placement of drains in the wound is mandatory. Anti-amebic treatment is instituted on confirmation of the diagnosis.

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PROGNOSIS OF CUTANEOUS MALIGNANT MELANOMA: A CLINICOPATHOLOGICAL STUDY*

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Summary: A retrospective study was done of the clinical findings and histological features of cutaneous malignant melanoma in 112 patients treated at the Winnipeg General Hospital between 1947 and 1967. The findings indicate that tumours in women, tumours in the younger age group and tumours in the upper extremity have a better prognosis provided the neoplasm has not spread beyond the primary site. The prognosis of melanoma correlates well with the depth of tissue invasion. Histological grouping appears to be of value in selecting patients for prophylactic node dissection. In this study, node dissection was found most useful in improving the survival of patients with intradermal lesions.

Résumé: Nous avons entrepris une étude rétrospective des données cliniques et des constatations histologiques des 112 cas de mélanome cutané malin traités à l'Hôpital Général de Winnipeg de 1947 à 1967. Il ressort de cette analyse que les tumeurs chez la femme, celles qui frappent les jeunes et celles qui se trouvent dans les membres supérieurs ont un meilleur pronostic, à condition que le néoplasme n'ait pas essaimé au-delà du foyer primaire. Le pronostic du mélanome était en excellente corrélation avec la profondeur de l'invasion tissulaire. Le groupement effectué suivant les données histologiques s'est révélé précieux pour choisir les malades devant subir une dissection nodale, à titre prophylactique. Dans notre étude, nous avons noté la grande valeur de la dissection nodale pour prolonger la survie des malades porteurs de lésions intradermiques.

RECENT reports indicate that the prognosis of malignant melanoma depends on a number of factors related both to the patient[1-3] and to the malignant potential of the tumour.[4-6] The clinician, however, is still faced with decisions in the management of these patients, particularly with regard to the extent of surgery required for the primary tumour and the advisability of prophylactic node dissection.

From a retrospective study of the clinical findings and histological features of cutaneous malignant melanoma in 112 patients treated at the Winnipeg General Hospital between 1947 and 1967 we have attempted to determine the factors that may influence management and prognosis of this disease.

MATERIAL AND METHODS

Only those patients were included who underwent part or all of their initial treatment at the Winnipeg General Hospital. The diagnosis of malignant melanoma was based on histological examination and lesions in all stages were included. Melanoma of the eyes, paranasal sinuses, viscera and mucous surfaces were excluded from this series. Clinical information was obtained from the medical records of the Winnipeg General Hospital, the tumour registry of the Manitoba Cancer Treatment and Research Foundation and records of the Radiotherapy Department. Follow-up data were compiled from inpatient and outpatient records, death records and, in some cases, direct inquiries to other hospitals and individual physicians.

CLINICAL DATA

The youngest patient was 19 and the oldest 96 years of age, the average age being 53 years (Fig. 1). The peak incidence of melanoma was in the sixth decade in men and the seventh decade in women. There were 64 women and 48 men, with a female: male ratio of 1.4:1. Fifty-seven percent of the women and 32% of the men were under 50 years of age.

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The most frequent sites of melanoma were the head and neck and the lower extremity (Table I). The trunk and upper extremity had a lower frequency relative to surface area. When analyzed according to sex, we found that lesions involving the head and neck occurred with almost equal frequency in the two sexes. The next most common sites in men were the trunk and lower extremity, whereas in women these were the lower and upper extremities. Tumours of the trunk were quite infrequent in women. In two patients the primary site was unknown; one presented with axillary node metastasis and the other with pulmonary metastasis.

Eighty-nine patients (79.5%) with tumour confined to the primary site were classified as Stage I, 16 patients (14.3%) with clinical evidence of metastases to the regional lymph nodes as Stage II, and seven patients (6.2%) with disseminated melanoma as Stage III (Table II). Of the 89 patients with Stage I disease, 61.8% were women and 38.2% men. When related to age and sex, it was found that the majority of Stages II and III patients were men over the age of 50 years.

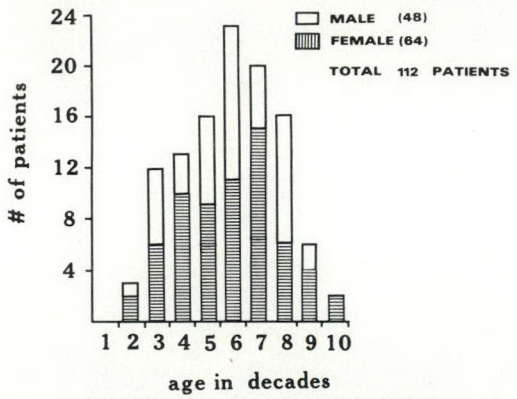

Fig. 1.—Age and sex distribution.

TREATMENT

Of the Stage I patients, 53 underwent local excision of the primary tumour, only 22 had local excision and subsequent dissection of clinically positive nodes occurring within one to five years after initial treatment, and 14 had local excision with prophylactic node dissection. There was no fixed policy regarding prophylactic node dissection, the decision being solely that of the attending surgeon. Thirteen Stage II patients underwent local excision with therapeutic node dissection and three had local excision with excisional biopsy of a regional lymph node. In the group undergoing prophylactic node dissection, four of 14 patients (28%) had metastases in the lymph nodes on histological examination. Of the patients subjected to therapeutic node dissection, six of 35 (17%) had no histological evidence of metastases in the lymph nodes.

In one patient with no identifiable pri-

TABLE I.—LOCATION OF THE LESION

	Women		*Men*		*Total*	
Location	*No. of patients*	*%*	*No. of patients*	*%*	*No. of patients*	*%*
Head and neck	22	34.3	16	33.3	38	33.9
Upper extremity	13	20.3	5	10.4	18	16.0
Lower extremity	21	32.9	13	27.1	34	30.4
Trunk	7	10.9	13	27.1	20	17.9
Unknown primary	1	1.6	1	2.1	2	1.8

TABLE II.—CLINICAL STAGE

	Women		*Men*		*Total*	
Stage	*No. of patients*	*%*	*No. of patients*	*%*	*No. of patients*	*%*
I	55	85.9	34	70.8	89	79.5
II	5	7.8	11	22.9	16	14.3
III	4	6.2	3	6.2	7	6.2

mary lesion, biopsy of a metastatic axillary lymph node was done. Six patients with advanced disease received no definitive surgical treatment except diagnostic biopsy, either of the cutaneous lesion or a metastasis; one patient of the six had no identifiable primary lesion. Palliative radiotherapy either alone or with chemotherapy was used in patients with recurrent or metastatic disease. No major amputations were done in this series either for cure or palliation.

Histological Findings

Slides of 60 patients were available for review by the pathologist (D.W.B.) without his knowledge of their clinical status. Factors such as mitotic index, pleomorphism, pseudoepitheliomatous hyperplasia, lymphoid infiltration, depth of invasion and vascular invasion were assessed. The most valuable indicator of prognosis appeared to be the depth of tissue invasion. Melanomas were classified into three groups according to the depth of invasion as described by Mehnert and Heard.[6] Group I or superficial lesions (Fig. 2) are those limited to the papillary dermis down to the depths of the rete pegs, Group II or intradermal lesions (Fig. 3) penetrate the reticular dermis down to appendage structures, and Group III or subcutaneous lesions (Fig. 4) involve

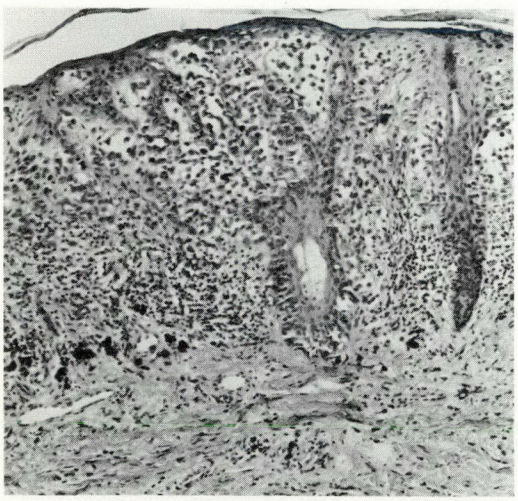

Fig. 2.—A cutaneous malignant melanoma showing a Group I or superficial lesion. The tumour is limited to the papillary dermis superficial to the deepest extension of the rete pegs, with considerable lymphocytic infiltration about the tumour (H & E x 400).

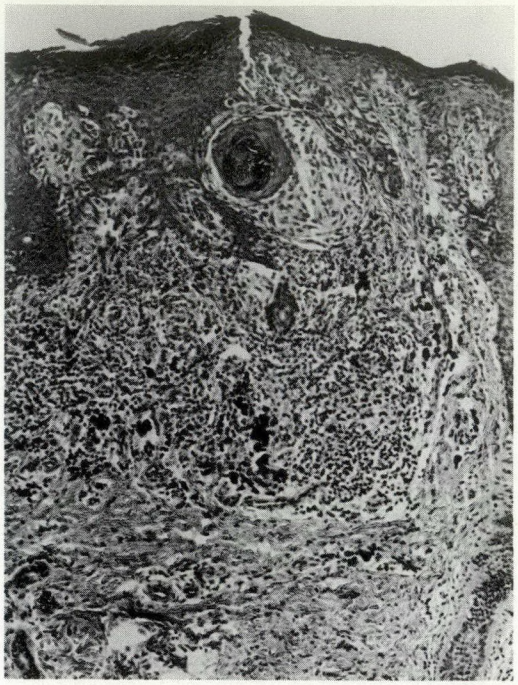

Fig. 3.—A cutaneous malignant melanoma showing a Group II or intradermal lesion. The tumour infiltrates the reticular dermis just superficial to the appendage structures with minimal lymphocytic infiltration (H & E x 400).

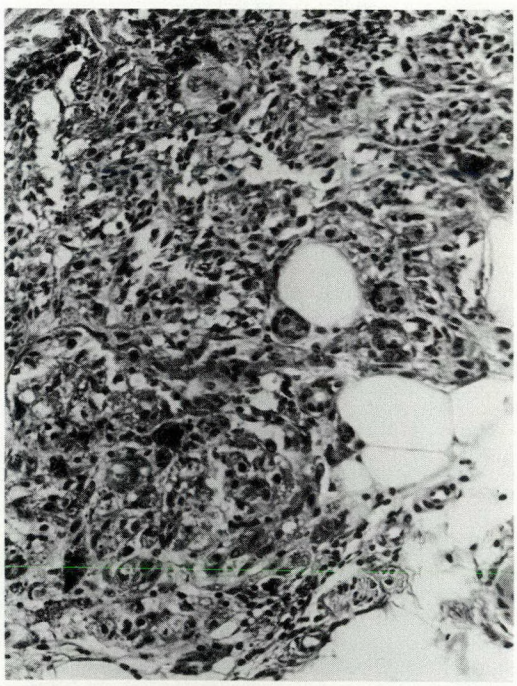

Fig. 4.—A cutaneous malignant melanoma showing a Group III or subcutaneous lesion. The tumour invades the subcutaneous fat (H & E x 400).

the subcutaneous fat. *In situ* or Group 0 lesions, e.g. Hutchinson's melanotic freckle, were excluded from this series. These generally occur on exposed surfaces in elderly patients, remain confined to the epidermal layer without breaking through the basement membrane for a long period of time and seem to have much better prognosis than invasive melanoma.[7, 8] Eighteen patients were found to have Group I, 27 Group II and 15 Group III lesions.

Clark *et al*[5, 8] have defined five levels of tissue invasion (levels I to V). This classification is similar to that of Mehnert and Heard,[6] which is the one used in this study, except for the inclusion in the latter of one additional category where tumour extends right to the junction of the papillary and reticular layers of the dermis without invading the latter. However, we found it impossible to distinguish this category in histological examination of several sections of the same tumour because of the variable depths of the rete pegs and the skin appendages.

Results

One hundred and nine patients have been followed up for at least five years. Seventy-six patients are dead, 29 are alive without disease and four with disease. Sixteen are alive without any evidence of their disease 10 years or more since their initial treatment, and three patients have been lost to long-term follow-up. Ninety-five patients were alive at the end of one year, 63 at the end of three years and 51 at the end of five years, giving an average five-year survival rate of 42%.

Survival related to age and sex.—Survival rates seemed better in women than in men (Fig. 5), irrespective of the age. The five-year survival rate was 54.1% in women and 21.4% in men. The patients were arbitrarily divided into two groups, above and below 50 years of age. Five-year survival was better in individuals under 50 years of age than in those over 50 (Fig. 6).

Survival related to location of the lesion (Fig. 7).—Melanoma of the upper extremity seemed to have the best, and those occurring on the trunk the worst, prognosis. Survival at five years was 56.2% for upper-extremity lesions, 44% for head and neck lesions, 41.9% for lower-extremity lesions, and 22.2% for trunk lesions.

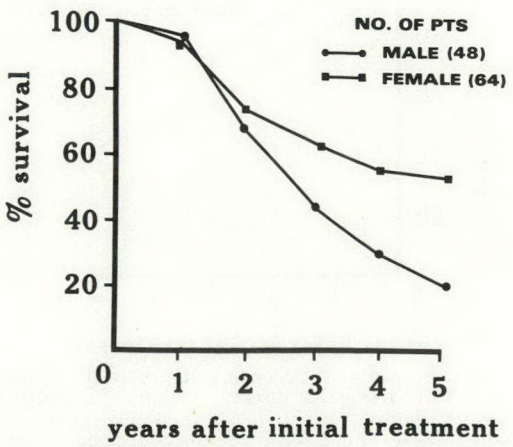

Fig. 5.—Survival according to sex.

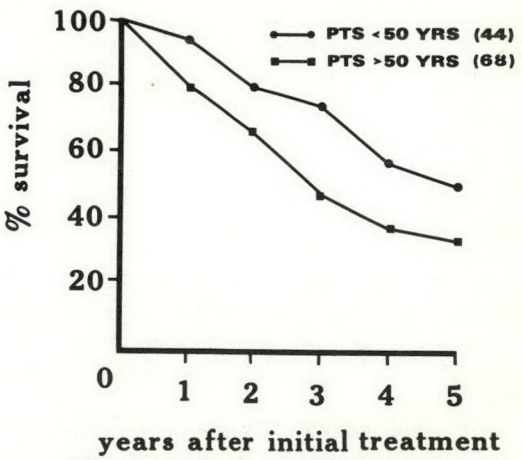

Fig. 6.—Survival according to age.

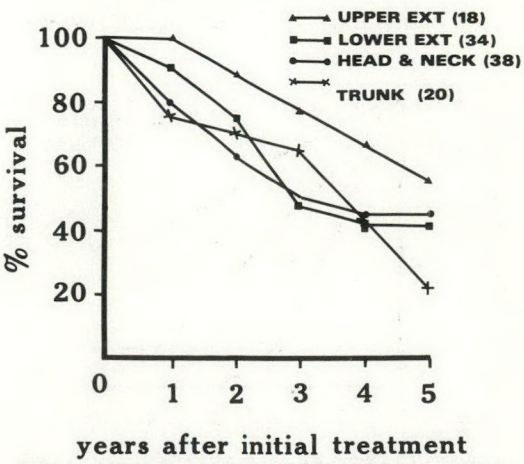

Fig. 7.—Survival according to location of the lesion.

Survival related to clinical stage (Fig. 8).—The prognosis of patients with Stage I disease was significantly better than of those with Stage II disease, five-year survival being 46.6% in the former group compared with 13.3% in the latter. Only one patient with Stage III disease survived two years and none lived longer than three years.

Survival related to treatment.—Of the 53 Stage I patients who underwent local excision alone, 26 (49%) survived five years. In this group, 20 of 37 women, but only six of 16 men, survived five years. Of the 22 Stage I patients who were initially treated with local excision only but later underwent therapeutic node dissection, six (27%) lived for five years from the time of initial treatment. In this group also the women fared better than the men. Thus, of the 75 Stage I patients who did not undergo prophylactic node dissection initially but were observed for nodal metastases, 33 (44%) survived for five years. In contrast, of the 14 Stage I patients who underwent prophylactic node dissection, seven (50%) lived five years. In this group seven of 10 women but none of the four men survived for five years, again suggesting a better prognosis in women. It is evident from Fig. 9 that the prognosis of patients who underwent prophylactic node dissection was always better than for those who did not over a five-year period, although the difference is not statistically significant.

Survival related to histological features.—To correlate depth of invasion with the prognosis of the disease, slides of 43 patients with Stage I disease were reviewed. According to depth of invasion, six were classified as Group I, 25 as Group II, and 12 as Group III lesions. The survival in Stage I melanoma according to depth of invasion and treatment method is presented in Table III. Survival in these patients correlates well with the depth of invasion. In Group I lesions local excision alone resulted in five-year survival of four out of six patients. In Group II lesions local excision with or without prophylactic node dissection resulted in five-year survival of all of four patients and 10 of 21 patients respectively. In Group III lesions none of the seven patients undergoing local excision survived five years. With local excision and prophylactic node dissection only one of five patients survived five years.

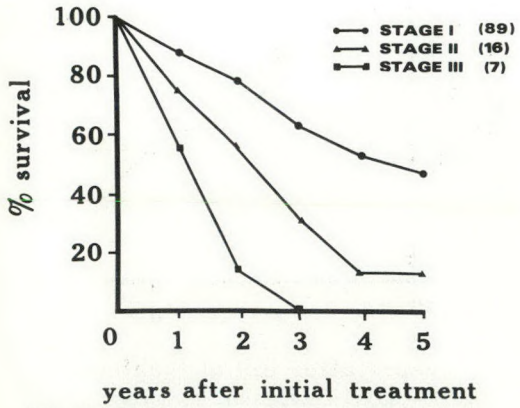

Fig. 8.—Survival according to clinical stage.

Discussion

Our findings indicate that tumours in women, tumours in the younger age group and tumours in the upper extremity have a better prognosis provided the neoplasm has not spread beyond the primary site (Stage I). Others have also reported a better survival for women[1, 2, 9-11] and younger patients,[12] although these conclusions have been disputed.[13, 14]

In this study, lesions of the upper extremity had the best prognosis, as was reported by McLeod *et al*[15] and tumours of the trunk had the worst, as reported by

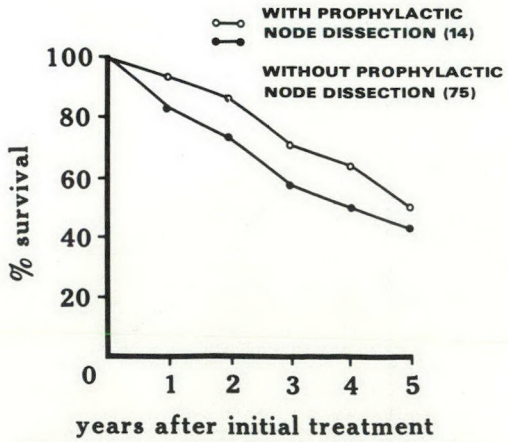

Fig. 9.—Survival according to treatment in patients with Stage I disease. Of the 75 patients treated without prophylactic node dissection, 22 subsequently underwent therapeutic node dissection.

others.[2, 10, 11, 13] Perhaps late diagnosis and variable lymphatic drainage may contribute to the grave outlook of melanoma of the trunk as suggested by these authors.

Clinical stage is the single most important factor influencing prognosis. In this series as well as in those of others,[2, 3, 10, 16, 17] it is evident that when malignant melanoma has spread beyond the primary site none of the current methods of treatment is effective in controlling the disease. Therefore of paramount importance are early diagnosis and definitive treatment when the tumour is still confined to the site of origin.

Our findings suggest that patients with Stage I disease had a better prognosis with prophylactic node dissection than without (Fig. 9), as previously reported.[2, 3, 9, 10, 14, 15, 17-21] A regional basis for elective node dissection is also supported by the fact that five out of 14 patients who were classified as belonging to clinical Stage I were found to have histological evidence of metastasis in their dissected lymph nodes. Fortner *et al*[22, 23] showed that 21.9% of patients with melanoma of the trunk and 38% with melanoma of the lower extremity with clinically negative nodes had microscopic metastases found in electively excised lymph nodes. They[22, 23] and others[17, 19] have also reported that the patients with clinically negative and histologically positive lymph nodes had a better prognosis after elective node dissection than those undergoing therapeutic node dissection for clinically positive nodes. On the basis of survival figures, the difficulty of assessing the status of regional lymph nodes, and the grave prognosis associated with Stage II disease, it seems that elective dissection of clinically tumour-free nodes should be favoured. However, other authors[24, 25] do not share this view except in special circumstances, e.g. where the primary lesion is near the regional lymph node and thus can be excised in continuity. These authors have also suggested that other factors, including the size of the lesion, its anatomic location and the depth of invasion, should be considered in selecting patients for prophylactic node dissection.

The findings of the histological study suggest that prognosis for clinical Stage I disease correlates well with the depth of invasion as reported by others,[4-8] Group I lesions having the best and Group III the worst prognosis. None of the patients with Group I lesions underwent prophylactic node dissection, precluding a valid comparison of results of local excision with and without prophylactic node dissection. However, survival figures following local excision alone are encouraging, and a small improvement in survival rate may not justify the increased morbidity associated with prophylactic node dissection as indicated by Mehnert and Heard.[6] Patients with Group III lesions, with or without prophylactic node dissection, had poor survival. Prophylactic node dissection seemed most useful in improving survival of patients with Group II lesions since the results with node dissection are clearly better than without. Thus, depth of invasion appears to be an important factor in the prognosis of melanoma patients and may be of value in selecting patients for prophylactic node dissection. Further prospective study is required to verify this.

TABLE III.—SURVIVAL IN STAGE I MELANOMA ACCORDING TO DEPTH OF INVASION AND TREATMENT METHOD

Depth of invasion	*Type of operation*	*No. of patients*	*Five-year survival*
Group I (superficial)	Local excision only	6	4
Group II (intradermal)	Local excision only	21	10
	Local excision with prophylatic node dissection	4	4
	Total	25	14
Group III (subcutaneous)	Local excision only	7	0
	Local excision with prophylactic node dissection	5	1
	Total	12	1

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DELAYED ARTERIAL EMBOLECTOMY*

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Summary: The belief that poor results are to be expected from embolectomy performed more than eight to 12 hours after acute occlusion of an artery should be modified. It has become increasingly apparent that there is a group of patients who suffer an embolus to an extremity but who retain a viable limb for several weeks after the insult. It is in these patients that delayed embolectomy is advised. A limb that is severely ischemic and pregangrenous cannot tolerate this long interval.

Résumé: Nous estimons qu'il faut réviser l'opinion qu'une embolectomie pratiquée plus de huit à 12 heures après l'occlusion aiguë d'une artère risque de donner des résultats médiocres. Il est devenu de plus en plus évident qu'un certain nombre de malades qui ont souffert d'un embole à une extrémité conservent un membre viable pendant plusieurs semaines après cette lésion. C'est chez ces malades qu'on conseille de retarder l'embolectomie. Par contre, les malades dont le membre est gravement ischémique et dans un état de prégangrène ne peuvent tolérer ce long retard.

SUDDEN embolic occlusion of a major artery is followed in most instances by vascular necrosis of the tissue supplied by it. In the lower limbs, the likelihood of gangrene is extremely high if treatment is delayed for more than eight to 12 hours. There is general agreement that the earlier an embolus is removed, the better is the outlook for the patient. However, if the limb is still viable, irrespective of the time that has elapsed since the onset of occlusion, embolectomy may be successful. Late embolectomies are well documented by various authors. In different series the success rate of embolectomy ranges from 40% to 90%.[1-5]

The following seven cases are presented to emphasize that late embolectomy can be rewarding. The impression that a poor result is to be expected when the operation is performed more than eight to 12 hours after acute occlusion of the artery should be modified.

CASE REPORTS

Case 1.—W. C., a 54-year-old white man, was admitted to hospital in a state of shock due to myocardial infarction. One week later he complained of sudden pain, loss of sensation and weakness in the left leg. Both femoral pulses were present but the distal pulses could not be felt on the left side. The left leg and foot were cold and pale. As the patient's general condition was too poor to allow immediate embolectomy, heparin was used systemically. Seventy-two hours later, in spite of his poor condition, embolectomy was done using a Fogarty balloon catheter. The patient had a straightforward recovery.

Case 2.—R. MacI., a 77-year-old white woman with auricular fibrillation, underwent an appendectomy for acute appendicitis. On the sixth postoperative day she developed increasing pain and paralysis in the left leg. The limb was cold, discoloured and paralyzed. The left femoral pulse was present but the distal pulses were absent. The electrocardiogram supplied evidence of myocardial infarction and 24 hours later the patient was referred to us for an embolectomy. The operation was carried out using a Fogarty balloon catheter. The patient made an uncomplicated recovery and was discharged home three weeks later.

Case 3.—G. B., a 79-year-old white man with atrial fibrillation, was admitted to hospital on March 11, 1969. One week earlier he first noticed pain, anesthesia, and bluish discolouration of the left hand. Two days later he developed pain in, and paralysis of, the left leg. On examination the left arm and hand were pulseless but viable. The left leg was discoloured and paralyzed. The left femoral pulse was absent as well as the distal pulses. An embolus was removed from the common femoral artery under local anesthesia. In the postoperative period the patient received heparin and the left leg remained viable although the pedal pulses did not return. The brachial artery embolus was not treated surgically as

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the hand was viable and sensation returned to normal.

Case 4.—W. C., an 80-year-old white man, was transferred from a sanatorium, where he had been treated for active pulmonary tuberculosis, because of pain, paresthesia and discolouration of the left leg of 24 hours' duration. The limb was cold, discoloured and paralyzed; the left femoral pulse was present but the distal pulses were absent. An intravenous heparin drip was started and an emergency left femoral embolectomy was successfully performed. Anticoagulants were given during the postoperative period and the leg remained viable and the pedal pulses returned.

Case 5.—K. M., a 75-year-old white woman, had a three-week history of pain and pallor in her left foot and calf of sudden onset. She was known to have atrial fibrillation, and three months previously she had undergone a right femoral artery embolectomy with a good result. The femoral pulses were palpable but the distal pulses in the left lower extremity were absent. A femoral arteriogram showed blockage of the femoral artery proximal to the knee joint with no arterial visualization distal to this point. After operative removal of the embolus from the popliteal artery, using a Fogarty balloon catheter, her recovery was uneventful and she was discharged home on a regimen of long-term anticoagulants.

Case 6.—P. B., a 23-year-old man, was admitted to hospital because of severe pain in the right leg for two days. Two years earlier he had suffered pulmonary embolism and three months before he was treated for recurrent pulmonary embolism and thrombophlebitis. Two weeks before this admission a laparotomy had been performed for acute abdominal symptoms but no abnormality was discovered. He had an uncomplicated postoperative course and was discharged home on the tenth day. He was readmitted two days later because of severe pain in his right leg. The leg was pale and the calf was markedly tender. The right femoral pulse was present but the distal pulses were absent. In view of the previous history the diagnosis of recurrent deep thrombophlebitis with associated arterial spasm was made but no improvement was obtained by conservative treatment. A femoral arteriogram (Fig. 1) showed a blockage of the popliteal artery. After embolectomy using a Fogarty balloon catheter, his recovery was uneventful with the return of the pedal pulses. The interval between the onset of the embolism and operation was seven days. The postoperative femoral arteriogram was normal (Fig. 2). The source of his embolus could not be found.

Case 7.—J. D., a 67-year-old man, was admitted to hospital because of rest pain and intermittent claudication in his right leg of one month's duration. Three months before he had had a myocardial infarction. One year previously he had had a femoropopliteal autogenous vein graft on his left leg with a successful result and a similar operation had been performed on his right leg four months before his most recent admission. A month after the second operation he developed sudden pain in his right foot and symptoms of claudication; there was no pulsation in the femoral graft and his symptoms were attributed to graft closure.

A femoral arteriogram following admission showed a patent vein graft but there was segmental occlusion of the popliteal artery for a distance of 4 cm. A lumbar sympathectomy was done and the popliteal artery was explored below the graft. An embolectomy was carried

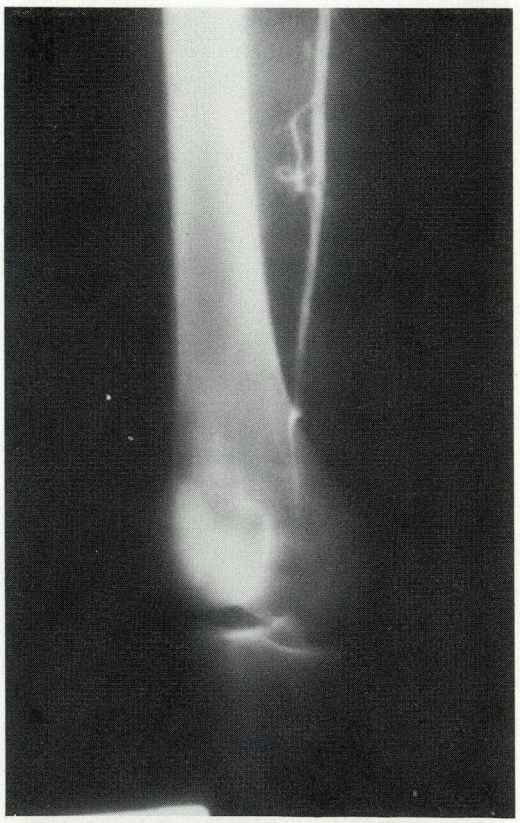


Fig. 1.—Case 6. Preoperative femoral arteriogram showing complete obstruction above the knee with no distal arterial opacification.

out utilizing a Fogarty balloon catheter, with return of the pedal pulses. The source of the embolus was intracardiac.

Discussion

Delayed embolectomy is receiving considerable attention in the current medical literature.[1, 2, 5-8] Billig, Hallman and Cooley[9] reported on 31 patients in whom embolectomy was performed more than 12 hours after embolization. They noted that loss of neuromuscular function is an important factor in prognosis irrespective of the length of delay. Successful embolectomy in these patients is explained by the hypothesis that clot extends into small inaccessible arteries only after muscle necrosis has occurred. A clinical corollary is that a vigorous surgical attack on any embolized extremity, regardless of its duration, is warranted as long as muscle necrosis has not developed.[4]

In most instances emboli have an intracardiac origin and the occurrence of acute ischemia of a limb in a patient with atrial fibrillation constitutes the classical clinical presentation. In the presence of good collateral vessels the severity of the ischemia is not so marked and clinical deterioration progresses gradually in a manner closely resembling that of progressive arteriosclerotic obliteration. Eventually rest pain and gangrene supervene in a substantial proportion of cases.

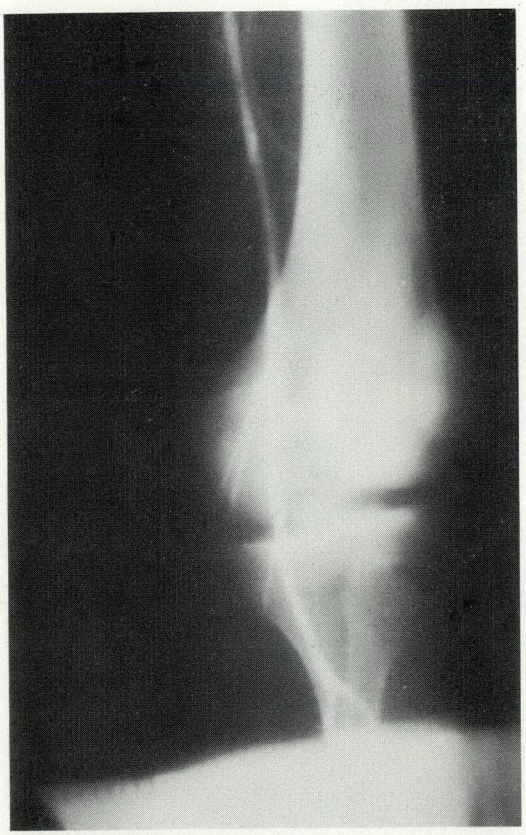


Fig. 2.—Case 6. Postoperative femoral arteriogram showing patent femoral vessel.

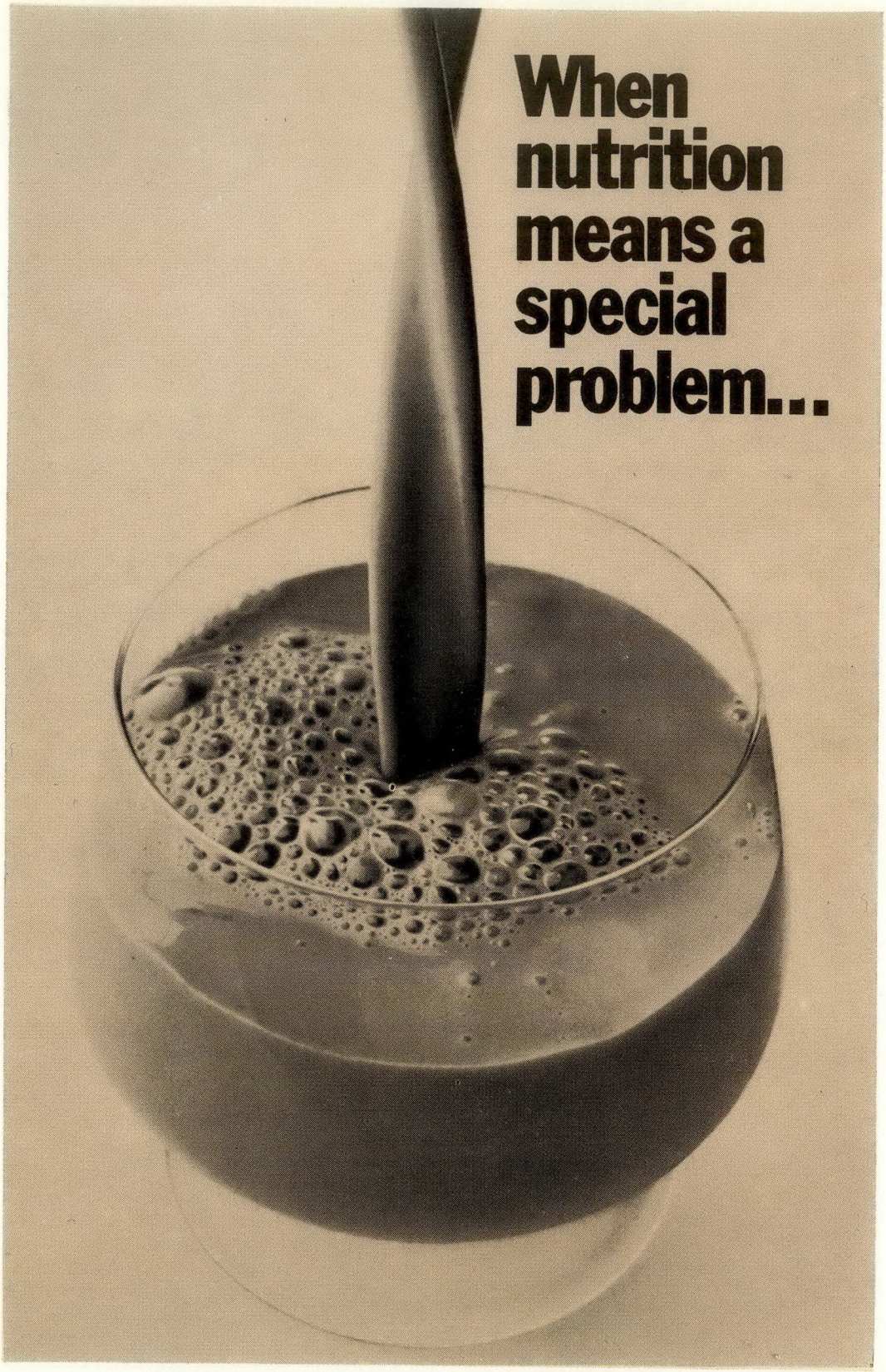
The correct diagnosis depends largely upon clinical suspicion and the observation of localized occlusion on angiography in otherwise apparently normal vessels.

The introduction of the Fogarty balloon catheter technique of embolectomy has greatly simplified the surgical management of the condition. It is now possible to perform major embolectomies under local anesthesia in extremely ill patients whose likelihood of survival would otherwise be seriously compromised by the effects of toxic absorption and subsequent amputation.

Certain details of operative technique assume critical importance when extensive clots have formed in the distal arterial tree. The femoral vessels are exposed through longitudinal incisions made directly over the occluded artery. The operative approach to the popliteal artery varies with the position of the patient. In embolism of the popliteal bifurcation exposure is commonly obtained through a below-knee incision placed near the medial edge of the tibia. Immediately following localization and isolation of the affected vessel heparin, 50 mg, is given intravenously and the embolus is removed by means of a Fogarty balloon catheter passed first to the distal and then to the proximal end of the vessel.

Following removal of the embolus some distal thrombi may be removed by digital compression of the muscle in the extremity. If there is no free back-bleeding a distal arteriotomy is made of the posterior tibial vessel and the intervening segment of the artery is flushed vigorously with saline solution. If the saline irrigation is ineffective, an endarterectomy stripper or catheter is introduced through the tibial vessel and passed upwards to the proximal arteriotomy site in order to dislodge and remove clot.

Embolectomy most often fails because of incomplete removal of distal thrombi. This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occurs because clinical findings indicating residual thrombi are unreliable unless a pulse can be palpated at the ankle. Arteriography at the time of operation is the simplest and most reliable method of evaluating patency of the distal arterial tree. It is performed by injecting sodium diatrizoate, 10 to 15 ml of 50% solution, into the lower end of the distal arteriotomy. Complete removal of the clot is confirmed by finding an arterial tree patent in the ankle.

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SECRETORY FUNCTION OF TOTALLY ISOLATED PORCINE STOMACH PERFUSED EX VIVO WITH HOMOLOGOUS BLOOD: EFFECT OF HISTAMINE*

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Summary: The authors describe a method of isolation and *ex vivo* perfusion of the whole porcine stomach. The stomach was perfused extracorporeally with homologous blood of a supporting pig which served as a living oxygenator and dialyzer. Histamine given by intra-arterial infusion was used as a secretagogue. Samples of gastric juice and blood were collected every 30 minutes during the perfusion period for analysis. All porcine stomachs secreted H^+ and pepsin. The results demonstrated that *ex vivo* porcine stomachs secreted about one-third of the volume and acid but about five times more pepsin than did canine stomachs in similar situations. This new experimental tool appears to be adequate for the study of gastric secretory function of the porcine stomach.

Résumé: Les auteurs décrivent ici une méthode permettant l'isolement et la perfusion *ex vivo* de l'estomac de porc entier. L'estomac a été perfusé en dehors du corps par du sang homologue et un porc de soutien servant d'oxygénateur et de dialyseur vivant. Comme sécrétagogue, on a utilisé de l'histamine par voie intra-artérielle. Pendant l'expérience, nous avons recueilli, toutes les 30 minutes, des échantillons de suc gastrique, aux fins d'analyse. Chez tous les porcs ayant servi à l'expérience, l'estomac a sécrété H^+ et de la pepsine. Il résulte de cette expérience que l'estomac de porc *ex vivo* a sécrété près d'un tiers du volume de suc gastrique et d'acide, mais environ cinq fois plus de pepsine que l'estomac de chiens placés dans des conditions similaires. Ce nouvel outil expérimental semble convenir à l'étude de la fondation sécrétoire de l'estomac du porc.

MOST available literature on the porcine stomach is concerned with spontaneous[1-5] and experimental[6-9] peptic ulcer. Despite the biomedical and economic importance of gastric ulcer in the pig and the apparent relationship between gastric secretion and ulcer in a variety of animal species, little is known about gastric secretory function of the porcine stomach. In a series of pigs bearing a gastric fistula or Heidenhain pouch and used for the induction of experimental ulcers, only gastric HCl, chloride and pepsin were studied.[6] Histamine-stimulated gastric secretion of HCl and pepsin were investigated in miniature swine bearing gastric fistulas.[10] No information appears available regarding the effect of various humoral or cholinergic stimulants on gastric secretion of domestic swine.

We found previously that various aspects of gastric secretory function can be investigated using a totally isolated canine stomach, perfused extracorporeally with homologous blood.[11-17] To our knowledge, no study of the totally isolated porcine stomach has ever been reported.

The present preliminary report describes a method of isolation and *ex vivo* perfusion of the whole stomach of domestic swine. We also present experimental evidence that the isolated porcine stomach may be used for the study of gastric secretory function.

MATERIALS AND METHODS

Animals

For each perfusion experiment we used two pigs, one as the stomach donor, another as the "supporting animal". "Supporting animal" means an anesthetized pig supplying oxygenated blood to the perfusion circuit. This pig served as a living oxygenator and a dialyzer. It supplied homologous blood by perfusion to the stomach of another pig. As in our studies on canine stomachs, the whole stomach of the donor animals was totally isolated for *ex vivo* homologous perfusion. Body weights of pigs used in this study varied from 28 to 32 kg. Before describing the surgical procedure and perfusion system, we shall discuss briefly some aspects of the morphology of the pig stomach.

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Gastric Mucosa in the Pig

Topographic distribution of various regions of mucosa in the porcine stomach is different from that observed in the canine stomach routinely used for experimental purposes. A small non-glandular esophageal region, absent in the dog, constitutes the first portion of the pig stomach. The non-glandular cardiac region, very small in the dog, is very large in the pig and occupies about half of the stomach. The region of fundic glands extends over half of the stomach of the dog, but occupies only about one-quarter of the pig stomach. Finally, the pyloric region, amounting to more than one-third of the canine stomach, represents only about one-quarter of the porcine stomach. In the pig, cardiac glands contain mucus-secreting cells, chief cells and gastrin-secreting cells; the fundus glands contain both chief and parietal cells; the pyloric glands produce mucus and gastrin. Characteristic species differences of the pig stomach are:

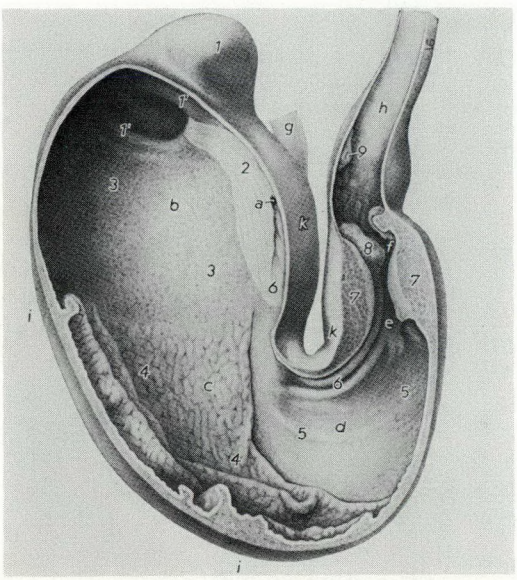

Fig. 1.—Anatomy of the pig stomach. a = cardia; b = fundus; c = body; d to e = pyloric part, d = pyloric antrum, e = pyloric canal; f = pyloric opening; g = esophagus; h = cranial part of duodenum; i = greater curvature; k = lesser curvature. 1 = gastric diverticulum; 1' = spiral fold at base of gastric diverticulum; 2 = proventricular part of mucous membrane; 3 = cardiac gland region; 4 = region of proper gastric glands with high folds; 5 = pyloric gland region; 6-6 = gastric groove; 7 = pyloric sphincter; 8 = torus pyloricus; 9 = major duodenal papilla with opening of bile duct. (Reproduced by permission from Nickel *et al*[19].)

the presence of deep mucosal folds and of many lymph nodules in the cardia and the distribution of parietal cells of the fundus in clusters.[18] Fig. 1 shows the stomach of the pig opened at the visceral surface.[19]

Perfusion System

Fig. 2 shows schematically the blood flow circuitry used in the present experiment. The perfusion chamber housing an *ex vivo* organ assures a precise control of temperature, humidity and pressure. Blood is delivered to the stomach with the help of an occlusive roller pump.[11-13, 15] Arterial blood flow rate can be arbitrarily raised by adjusting the pump speed selector, or it can be controlled automatically to deliver a constant, selected, arterial perfusion pressure. The latter facility utilizes a feedback channel responding to the galvanometer voltage from an arterial pressure channel on a recorder. The height-adjustable reservoir receives venous outflow blood from the stomach. A second roller pump returns blood to the supporting animal[11-13] at a rate that is automatically controlled by photoelectric sensing of the blood level in a venous reservoir.[20]

A small amount of blood escaping from the perfused stomach is delivered by a third pump to the venous circuit. Priming volume of the entire flow circuit is about 400 ml.

Anesthesia

No preoperative medication was used. Each pig was anesthetized, after a 24-hour fast, with a mixture of halothane (Fluothane, Ayerst Laboratories, Montreal, Que.) and air, using a Fluotec Mark III anesthetic machine (Fraser, Sweatman Canada Ltd., Scarborough, Ont.). Anesthesia was induced directly by means of a face mask at a flow rate of 5 l/min and a halothane concentration of 5%. Once surgical anesthesia was accomplished, the pig was placed supine and intubated with an inflatable cuffed 6-mm endotracheal tube which had been lengthened by the addition of a 10-cm section of plastic tubing. A small stiff metal rod was inserted into the endotracheal tube to facilitate its introduction and then removed. The tube was inflated, connected to the anesthetic machine and anesthesia

maintained at a flow rate of 2 l/min and a concentration of 1%.

Stomach for Perfusion

During dissection of the donor stomach, we attempted not to handle it and limited our work essentially to the vascular system. The purpose of surgery was to mobilize the entire organ with preservation of all gastric vascular arcades intact. Because splenic vessels are located deeply in the splenic hilus, splenectomy appeared difficult to perform without serious damage to gastric branches. We therefore left the spleen attached to the dissected stomach. Major steps of dissection were as follows: (a) laparotomy; (b) dissection of the major omentum; (c) isolation and removal of the small and large intestine, with exception of the cranial part of the duodenum, about 5 cm distal to the pyloric sphincter; (d) total pancreatectomy; (e) bilateral thoracotomy through both crura of the diaphragm and central tendon; (f) isolation, ligation and trans-section of the esophagus about 3 cm cranial to the cardia; (g) isolation of the portal vein and dissection of the minor omentum; (h) heparinization of the animal; (i) ligation and transection of the postceliac and preceliac aorta and of the portal vein; (j) removal of the stomach with attached spleen; (k) weighing of dissected organs and cannulation of the preceliac segment of the aorta and portal vein (these cannulas were later connected with the arterial and venous perfusion circuit [Fig. 2] when the stomach was placed in the chamber); (1) cannulation of the stomach through the pyloric sphincter; (m) placement of the stomach in the chamber. The transfer period, equivalent to the complete arrest of circulation and anoxia, lasted from eight to 10 minutes.

Supporting Pig

The anesthetized animal was connected with the perfusion circuit using the right carotid artery and vein cannulated with appropriate vinyl catheters. The right fem-

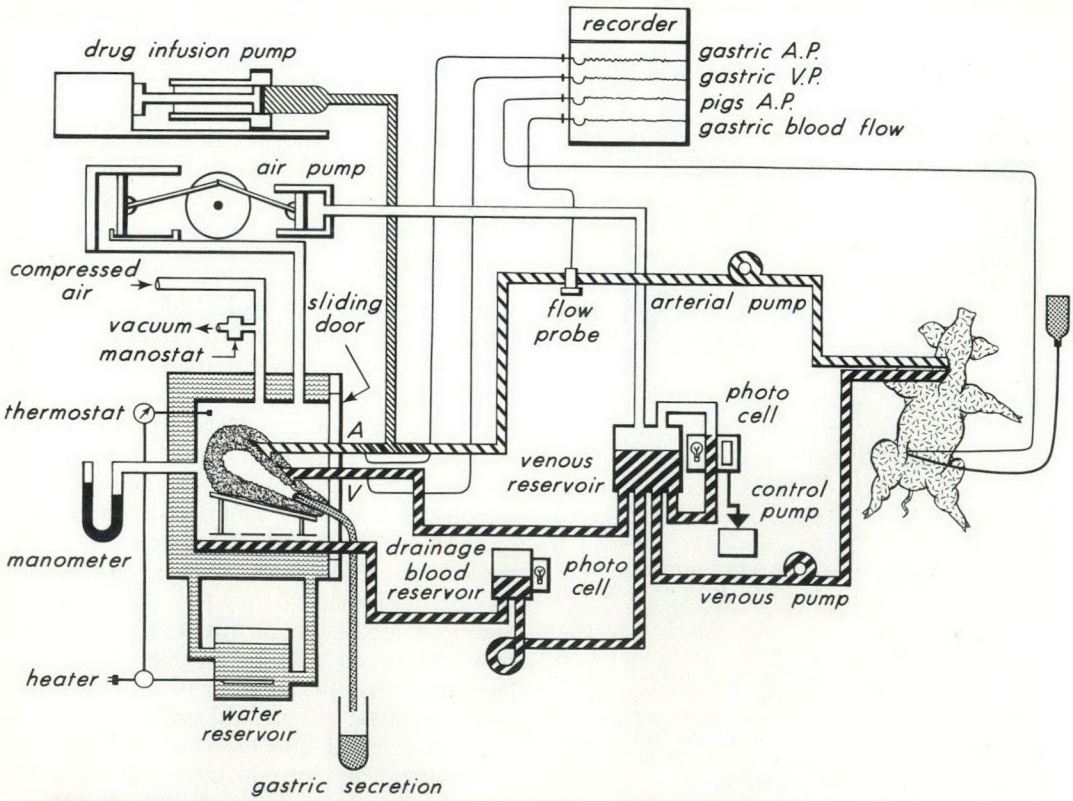

Fig. 2.—Circuitry for *ex vivo* homologous perfusion of isolated whole porcine stomach. A supporting pig supplies perfusion blood and serves as oxygenator and dialyzer.

oral artery was cannulated with a polyethylene tube which was connected to a transducer and blood pressure recorder. On completion of surgery the animal was heparinized and placed on its side, the optimal position for an anesthetized pig. As the supporting pig serves as an oxygenator and dialyzer of blood used for perfusion of the homologous stomach, it is carefully watched during the perfusion experiment: its respiration, blood pressure, temperature and blood gases are studied and recorded. Our experience with perfusion of canine stomachs indicates that deterioration of the supporting animal results in a rapid inhibition of secretory function of the isolated homologous stomach.

Perfusion

The stomach vasculature was connected with the perfusion circuit as explained above. The outlet of the intragastric cannula, secured by a ligature around the duodenal sphincter, was conducted outside the chamber. The chamber was closed and intermittent positive respiratory-rate pressures (3 to 8 mm Hg) were produced, using respiratory pumps. Venous reservoir height and pump volumes were adjusted to produce a pressure of 8 to 9 mm Hg in the portal vein. During the first 15 minutes of perfusion, the stomach, which was not washed after dissection, was permitted to drain spontaneously. Most of the pre-formed secretion was thereby evacuated. When circulation in the system was well stabilized and the stomach was emptied we began intra-arterial infusion of a secretagogue.

Stimulation

Using various doses of histamine dihydrochloride infused into the gastric artery of the *ex vivo* canine stomach, we found that 150 μg/hr represented a dose inducing maximal output of HCl in 30 minutes. We accepted this dose as maximal[13, 14, 17] for the isolated canine stomach. We had no information regarding the response of the porcine stomach *in vivo* to a parenteral dosage of histamine and we first used 150 μg/hr in our *ex vivo* experiments. We noted that with this dose the 30-min output of HCl was much lower in the porcine than in the canine *ex vivo* stomach. In a preliminary study we used various doses of histamine: 50, 150, 250 and 350 μg/hr, and we found that 150 μg/hr represented the maximal dose. Therefore we used 150 μg/hr of histamine dihydrochloride as the stimulant in the present study. The similarity of doses used in canine and porcine *ex vivo* stomachs facilitates comparison of secretory reactions of these two preparations with respect to their response to histamine.

Measurements

Arterial and venous blood from vessels of the isolated stomach was sampled every 30 minutes. Arterial and portal venous pressure and arterial flow rate were monitored. Arterial and venous Po_2, Pco_2, pH hemoglobin, hematocrit, bicarbonate, lactic and pyruvic acids, calcium, electrolytes[15, 16] and osmotic pressure were determined. Oxygen consumption was calculated using arterial flow rate, arteriovenous oxygen saturation difference and hemoglobin.[16] For determination of H^+ concentration and pH of gastric secretion we used an automatic titrator (Radiometer, model TTTI); total H^+ titrable to pH 7 was measured. Pepsin, electrolytes and osmotic pressure of gastric content were also analyzed. Analytical techniques and instruments used for these measurements have been previously described.[12-16] For calculation of significance we used Student's t test.

RESULTS

Perfused Stomachs

Seven stomachs were perfused for six to nine hours. During perfusion the behaviour of the stomachs was observed through the plexiglass windows of the chamber; colouration, state of vessels and mobility were periodically noted and recorded. No changes in colouration of the serosa and no congestion was noted in these stomachs, nor was any macroscopic damage of mucosa observed at the end of perfusion. This suggested that porcine stomachs tolerated well *ex vivo* perfusion. Canine stomachs are less resistant and, in about 10% of cases, show severe congestion and mucosal bleeding after seven to nine hours of perfusion. Contractions were observed and counted. For the first two to three hours they were hardly noticeable and occurred about six to seven

times per minute. After this period regular contractions of four to five per minute continued throughout the experiment. Weight of the stomach and spleen preparation averaged 551 g before perfusion and 571 g after perfusion. Change in weight during perfusion varied from −4% to + 6%. Change in the canine stomach always ranged between + 8% and + 12% and was considered due to marked edema. Only slight edema of the pyloric portion of the porcine stomach was observed after nine hours of perfusion.

Secretion

All *ex vivo* porcine stomachs secreted HCl and pepsin during histamine infusion. However, the first two to four 30-minute samples contained alkaline juice and H^+ appeared only in later samples. A progressive rise of H^+ continued for three to four hours and reached a plateau after four to five hours of perfusion. Table I shows the measurements of various components of gastric secretion. Because the "O" values were included in the calculation of H^+ output, this was low. However, the concentrations of H^+ were also low compared with those found in other animals. Interesting findings were the high output and concentration of pepsin. Table II and Fig. 3 show the difference between the pig and dog regarding secretion of HCl and pepsin by *ex vivo* gastric preparations.

As mentioned above, all stomachs studied secreted HCl. In one case, not included in this series, we lost the supporting pig before its connection to the perfusion circuit. The isolated stomach remained in normothermic total anoxia for 65 minutes, which was the time necessary to find another pig and prepare it for perfusion. We perfused this "anoxic stomach" without too much hope for the usual response to histamine. After four hours of secretion of alkaline juice, this stomach started to secrete titrable H^+ and

TABLE I.—MEASUREMENTS IN GASTRIC JUICE DURING THE PERFUSION OF *EX VIVO* PORCINE STOMACHS WITH HOMOLOGOUS BLOOD AND CONTINUOUS STIMULATION WITH 150 μG/HR OF HISTAMINE DIHYDROCHLORIDE, INFUSED INTO GASTRIC ARTERY

		Average	*Range*
No. of 30-minute collections	82		
Volume (ml/30 min)		16	0.5-46
HCl (mEq/30 min)		1.2	0-5.19
HCl (mEq/l)		59	0-121
Pepsin (mg/30 min)		147	6-434
Pepsin (mg/ml)		9.1	2.7-22.5
Na^+ (mEq/l)		68	10-145
K^+ (mEq/l)		10	4.5-26
Cl^- (mEq/l)		139	108-166
HCO_3 (mEq/l)		4	0-26
Osmotic pressure (mOsm/kg)		277	211-311

TABLE II.—MEASUREMENTS IN PERFUSION BLOOD* DURING PERFUSION OF *EX VIVO* PORCINE STOMACH WITH HOMOLOGOUS BLOOD. SAME STOMACHS AS IN TABLE I

	Average	*Range*
pH (a)	7.41	7.31-7.61
pH (v)	7.38	7.19-7.53
Hb (g/100 ml) (v)	9.0	6.7-10.6
Hct (%) (v)	28	21-35
Po_2 (mm Hg) (a)	94	36-165
Po_2 (mm Hg) (v)	49	22-63
Pco_2 (mm Hg) (a)	41	19-46
Pco_2 (mm Hg) (v)	40	20-45
Na^+ (mEq/l) (v)	137	130-146
K^+ (mEq/l) (v)	3.9	3.0-5.4
Cl^- (mEq/l) (v)	106	100-111
Ca^{++} (mEq/l) (v)	4.8	4.4-6.0
HCO_3 (mEq/l) (a)	19	10-26
HCO_3 (mEq/l) (v)	19	10-27
Lactic acid (mg/100) (a)	18	10-50
Lactic acid (mg/100) (v)	22	14-45
Pyruvic acid (mg/100 ml) (a)	0.9	0.4-1.4
Pyruvic acid (mg/100 ml) (v)	1.1	0.6-1.9
Osmotic pressure (mOsm/kg) (v)	304	293-327
O_2 consumption (ml/min/stomach)	3.8	0.7-7.5
Arterial blood flow (ml/min/stomach)	100	60-120

*Blood sample from gastric vein (v) or artery (a).

TABLE III.—VOLUME, HCl AND PEPSIN IN THE SECRETION OF PORCINE AND CANINE *EX VIVO* STOMACHS, STIMULATED WITH 150 μG/HR OF HISTAMINE, INFUSED INTO GASTRIC ARTERY

	Pig	*Dog**	*P*
No. of 30-minute collections	82	100	
Volume (ml)	16 (0.5-46)	36 (2-78)	<0.05
HCl (mEq/30 min)	1.2 (0-5.2)	5.2 (0.5-8.8)	<0.01
HCl (mEq/l)	59 (0-121)	119 (8-168)	<0.01
Pepsin (mg/30 min)	147 (6-434)	31 (6-73)	<0.01
Pepsin (mg/ml)	9.1 (2.7-22.5)	1.2 (0.1-2.2)	<0.01

*These 30-minute collections were taken, at random, from our experimental protocols on *ex vivo* canine stomachs. Some of these results were included in previous publications.[12, 13, 23, 26]

continued to do so for the remaining three hours. This appears to be an interesting example of temporary functional damage to the parietal cell. The delayed response of isolated stomachs to a secretagogue was observed in our experiments with *ex vivo* canine stomachs under various conditions of prolonged preservation.[21, 22] These studies as well as the experiment quoted above demonstrate the possibility of recovery of the parietal cell after temporary inhibition of its function.

Perfusion Blood

The composition of perfusion blood used in this study is given in Table III. There were no marked differences between porcine blood and canine blood, analyzed during perfusion of the *ex vivo* stomach. Some components of blood showed a very wide range of values, but this was also observed in studies of canine blood[14-16, 23] and we were unable to correlate such range differences with changes in gastric secretion. Certain basic requirements in the composition of perfusion fluid are *conditio sine qua non* of every successful organ perfusion[24] and these were carefully observed in our experiments. Perfusion of an organ with the blood of a living supporting animal depends upon many factors affecting both the composition and circulatory dynamics of this animal. As long as the supporting animal appears clinically normal, its blood is probably satisfactory as a perfusate of homologous isolated stomach. In the present study the supporting pig always survived the perfusion and after

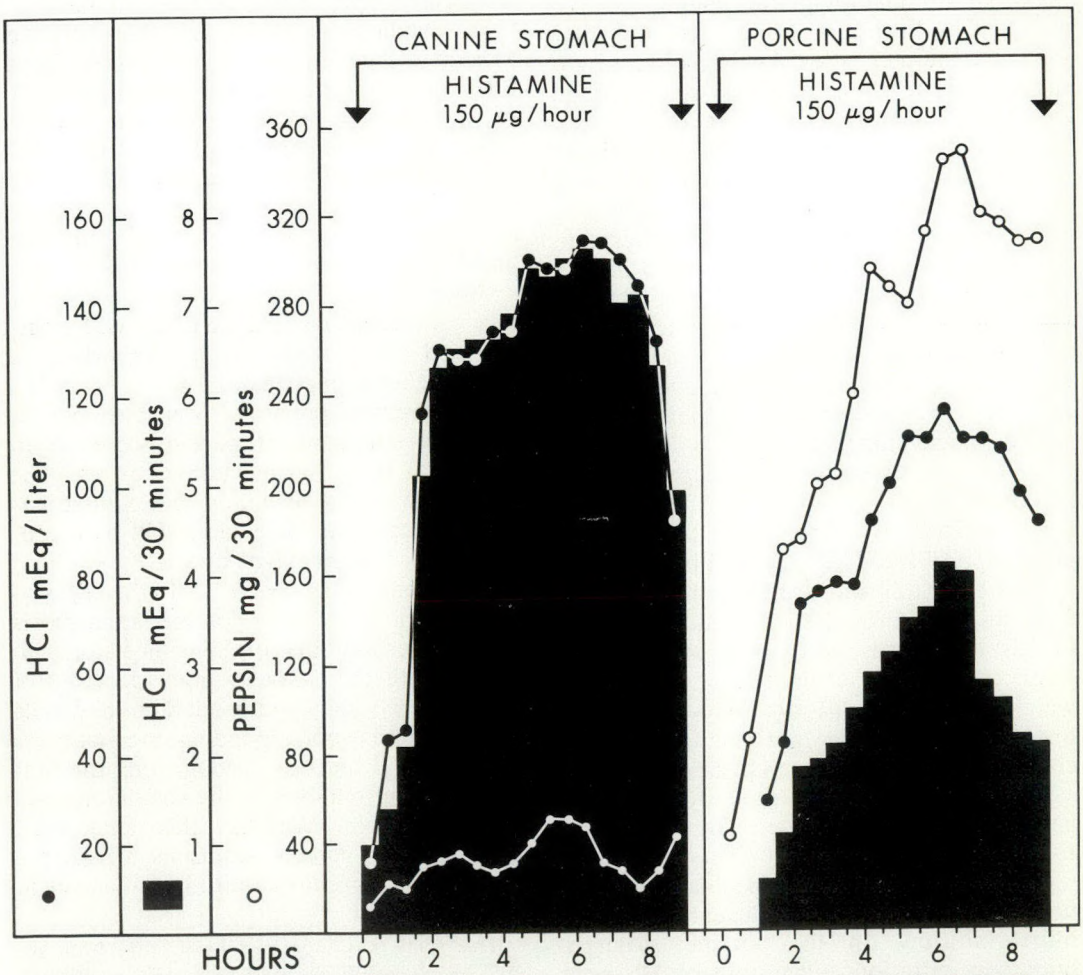

Fig. 3.—Comparison of the canine and porcine *ex vivo* stomach response to histamine infused into the gastric artery.

a few weeks of rest was used for another study.

Discussion

The results of experiments presented here provide baseline information concerning the use of the totally isolated whole porcine stomach for study of gastric secretion. This preliminary report shows that the stomach of the domestic pig can be isolated and *ex vivo* perfused with the blood of another pig. During such homologous perfusion the *ex vivo* stomach can be stimulated by infusion of histamine into the gastric artery. We found that all stomachs used secreted H^+ and pepsin during infusion of histamine. We also noted some interesting differences in the *ex vivo* secretion of HCl and pepsin between porcine and canine stomachs. With maximal stimulation of the canine *ex vivo* stomach by histamine, H^+ appears not later than 30 minutes after the initiation of infusion and, in 90% of cases, is present in the first 30-minute sample. In the porcine stomach the first two to four 30-minute samples to not contain titrable H^+ and then we observe a slow rise in H^+.

It appears from the available literature that the concentration of gastric acid in pigs is lower than in other animals. In a study of young pigs (average body weight 15 lbs) the concentration of free HCl in samples collected three hours after feeding averaged 22 mEq/l.[6] In another study, domestic pigs (body weight ranging from 10 to 37 kg) received an intramuscular deposition of histamine in oil. The dose used was ulcerogenic in 76% of animals. The highest concentration of free HCl observed in this series was 108 mEq/l and average values ranged from 31 to 66 mEq/l.[8] Intravenous infusion of histamine was used as a stimulant of gastric secretion in miniature pigs (body weight from 5 to 22 kg). With a dose of histamine considered maximal, the highest concentration of free HCl observed was 125 mEq/l.[10] In these three studies[6, 8, 10] gastric juice was collected from a simple fistula in non-anesthetized animals.

In the canine *ex vivo* stomach a concentration of 160 mEq/l is not unusual after histamine infusion. In the porcine stomach, both concentration and output of H^+ were much lower than in the canine stomach perfused under identical conditions. Output of free HCl *in vivo* in miniature pigs stimulated by the maximal dose of histamine averaged 1.40 mEq/kg/hr.[10] This is a much higher output than the one observed in the present experiment on *ex vivo* stomachs of domestic pigs. One should be reminded, however, that we use a totally denervated stomach. The enhancing role of the vagus nerve on histamine-induced gastric secretion is well known, particularly from the studies on cholinergic potentiation, also demonstrated in the canine *ex vivo* stomach.[13] Low output of HCl in the *ex vivo* porcine stomach is probably due, in part, to the absence of vagal tone. Another important cause of low H^+ concentration and output may be the neutralizing effect of alkaline secretion produced by the large cardiac mucosa and by the pyloric part of the porcine stomach.

As explained above, the acid-secreting area of the canine stomach occupies about 50% of gastric mucosa, but only about 25% of the porcine mucosa contains parietal cells. The contribution of the non-acid-secreting segments of the mucosa to the volume of secretion in the pig stomach is not known. In the future we will study this problem in porcine gastric pouches.

Another interesting difference between *ex vivo* canine and porcine stomachs is the output and concentration of pepsin which is much higher in pigs than in dogs (Table II). It was observed previously that histamine is a strong stimulant of pepsin secretion in pigs, as it is in rodents and primates.[10] It is also known that histamine is a poor stimulant of pepsin in dogs and this was confirmed in our *ex vivo* studies.[25, 26] It is worth mentioning again that the pepsin-secreting area of the porcine stomach is much larger than that of the canine stomach; in pigs both the cardiac region (deprived of parietal cells) and fundus contain chief cells and these areas correspond to three-quarters of the gastric mucosa. In dogs only the fundus, or about one-half of the gastric mucosa, secretes pepsin. Whether this anatomical peculiarity of porcine stomachs affects the secretion of pepsin quantitatively has yet to be investigated.

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BOOK REVIEWS

ACUTE URETERIC OBSTRUCTION. A Clinical and Radiological Study. P. M. Bretland. 219 pp. Illust. Butterworth & Co. Canada Ltd., Toronto; Butterworth & Co. (Publishers) Ltd., London, 1972. $20.25.

This book deals with the problem of acute ureteric obstruction based on the clinical and radiological findings in 150 patients. The author points out that some of the observed phenomena are not in accord with the conventional theory of this subject.

The discussion of renal anatomy and physiology is adequate to introduce the casual reader to this subject but the student of renal physiology will find it deficient in many areas. The account of the experimental work on the pathophysiology of acute ureteric obstruction is extensive and includes references to authors whose investigations were done in the early part of this century. A good deal of space is devoted to ureteral function, particularly pressure studies conducted by Narath, Risholm, Kiil, and others. This portion of the book is very informative. Several chapters are concerned with the explanation of the radiological findings in ureteric obstruction and compare these in chronic and acute obstruction. Readers will have a better understanding of the use of the intravenous pyelogram and in what clinical situations it is warranted.

The book is primarily a review of the literature related to obstructed renal function. No new clinical experimental evidence is presented but the continuing problems are indicated. The author offers a few guidelines for future research in the areas of vascular, tubular, and ureteric pressure and flow studies.

This book is well presented and written and contains a wealth of information and observations on the kidney and ureter. It should be of interest to nephrologists, urologists, and radiologists and those who are training in these specalties.

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ATLAS OF HAND SURGERY. Robert A. Chase. 438 pp. Illust. W. B. Saunders Company, Philadelphia; W. B. Saunders Company Canada Limited, Toronto, 1973. $30.90.

This atlas is an excellent textbook because of its concise elucidation of basic principles, the clear diagrams, and its extensive scope. A minor criticism would be the absence of an account of the anatomy of ligaments and ligamentous injuries to the joints of the hand. The sections on skin grafting, island pedicle grafts and amputation of fingers are extremely well done. It is refreshing to see a section on rheumatoid arthritis with discussion of resection and replacement arthroplasty.

This volume is recommended as a basic textbook for anyone who is called upon to perform hand surgery.

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FLEXIBLE IMPLANT RESECTION ARTHROPLASTY IN THE HAND AND EXTREMITIES. Alfred B. Swanson. 352 pp. Illust. The C. V. Mosby Company, St. Louis, 1973. $39.40.

The author, a pioneer in the development of flexible silicone rubber implants, has written an exciting, readable, surprisingly comprehensive book covering many aspects of his subject. It describes a wide variety of silicone implants, both experimental and in current use. The major emphasis, however, is on the place of implants in surgery of the rheumatoid hand.

The initial chapter deals with evolution of implant surgery—the development of bioengineering testing devices and the step-by-step improvement in design of the intramedullary finger prostheses from 1964 to 1969. The 1969 model design, for example, has increased the flex life of the former implants which averaged 124 million flexion-extension movements before cracks were noted in the material. Current clinical experience with these implants is discussed in some detail. Other chapters discuss effectively such matters as pathogenesis of arthritic lesions, pathologic mechanisms of hand deformities in rheumatoid arthritis, disability evaluation and operative considerations, in implant arthroplasty. The excellent illustrations and clear diagrammatic representations clarify the text.

One would have liked to see emphasis on the advantages of a close-working relationship between the rheumatologist and surgeon. Surgery in the rheumatoid patient should not be an isolated event and a combined approach facilitates overall management. Dr. Swanson states that most patients can be managed by the surgeon alone, though in another context he indicates that the trained therapist can complement the work of the surgeon. Rheumatologists working closely in a team situation would heartily endorse the trained therapists' contribution to successful rehabilitation.

There is an interesting discussion of the functional results of hand surgery. Unfortun-

ately, methods of meaningful preoperative and postoperative functional appraisal are not yet adequate. In the two studies quoted, results are based on such matters as joint range, pinch strength and grasp strength, but not on actual objective time-tested functional tasks. These will be applied, we are told, in the future. Questions as to the precise functional benefits of implant surgery, its results as compared with metacarpophalangeal excisional arthroplasty, and the *in vitro* life expectancy of implants, for example, are still incompletely answered. Functional testing is an area where the specialized occupational therapist can play an effective, objective third-party role.

The problems facing the anesthetist and surgeon are reviewed in some detail. One precaution omitted is the need to rule out atlantoaxial subluxation in the rheumatoid subject by lateral cervical radiographs in flexion because the high incidence of this complication represents a special hazard to the integrity of the cervical cord. Foreknowledge of this condition is critical to the anesthetist and surgeon.

In summary, despite some omissions and lack of emphasis on some details, the book provides a wealth of interesting information. While directed to the surgeon, both the rheumatologist and specialist therapist will find this volume of great interest.

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ORGAN PRESERVATION. A Symposium Held at the Clinical Research Centre, Northwick Park Hospital, Harrow. Edited by David E. Pegg. 286 pp. Illust. Churchill Livingstone, Edinburgh; Longman Canada Limited, Toronto, 1973. $18.00.

To those interested in organ preservation, the importance of this book is that it presents a comprehensive review of progress made on the European continent up to November 1972. It brings together some consensus of opinion in renal preservation, with lesser emphasis on liver and heart preservation. Current methods for perfusion, non-perfusion, cold storage and prediction of organ viability before transplantation are clarified and assessed.

Defects in even the best experimental studies include non-standardized models, interspecies extrapolation, unclear definitions of acceptable organ function and a paucity of clinically-tested experimental data. The main obstacles to successful preservation continue to be warm ischemia and donor deterioration. Short-term preservation of organs harvested in good condition appears to be most easily achieved by use of washout solutions which manipulate the extracellular environment and simultaneously cool the organ. Necessity for preservation periods in excess of 24 hours or the presence of sub-optimal harvest conditions appears to demand some form of perfusion technique which attempts to supply substrate for the reversal of cellular damage. Currently, renal preservation for more than 24 hours is best accomplished by perfusion, but there are still unsolved problems in hardware design, perfusate composition, acceptable perfusion parameters and the role of hyperbaric conditions. Studies of cellular metabolism have produced some ingenious new approaches to the prediction of organ viability but their application has been hampered by a lack of clinical testing.

This book is of interest mainly to specialists and suffers from the usual lack of cohesiveness seen in multiple-author symposia. It nevertheless offers good value as a reference for hard data and current bibliography in organ preservation. In addition, it provides stimulating suggestions for the researcher in quest of unsolved problems.

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THE PALMAR FASCIA. H. Graham Stack. 236 pp. Illust. Churchill Livingstone, Edinburgh; Longman Canada Limited, Toronto, 1973. $29.00.

This is a unique book and is highly recommended to those interested in both the anatomy and surgery of the hand. The author has been successful in attaining the goal that he has set out to achieve. He presents "an overall view of the problem based on an anatomical study with a strong surgical viewpoint".

A full account of the author's anatomical studies is included and is accompanied by superb reproductions of the cross-sections of fetal hands that the author studied in Landsmere's laboratory. Two chapters are devoted to the clinical features and treatment of Dupuytren's contracture; this alone is worth the modest cost of the book.

Any serious student of the hand will treasure this volume.

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POSTOPERATIVE DISORDERS OF THE GASTROINTESTINAL TRACT. Hastings K. Wright and M. David Tilson. 204 pp. Illust. Grune & Stratton, Inc., New York; Longman Canada Limited, Toronto, 1973. $16.75.

According to the authors this book was written as a partial answer to the surgical residents'

when shock threatens the lung

Abstract visualization of lung tissue

Solu-Medrol

helps reduce pulmonary damage and increase survival rates

- preserves lysosome and cell membranes, thereby preventing the release of destructive lysosomal enzymes[3]
- preserves platelets thereby reducing the risk of intravascular coagulation[1]
- preserves leukocyte integrity thereby helping to maintain the pulmonary architecture[1]

The recovery of patients in shock is often complicated by a pattern of deteriorating pulmonary function. This pulmonary insufficiency progresses despite restoration of hæmodynamic balance and apparent stabilization of the acute episode.

Under conditions of prolonged shock, lack of oxygen at the cellular level causes alterations in the oxygen-carbon dioxide exchange mechanism. These changes in cell metabolism lead ultimately to interstitial œdema and perivascular hæmorrhage.[1] Polymorphonuclear leukocytes aggregate in the pulmonary capillaries and obstruct the pulmonary vascular bed. As these trapped cells break down, they release lysosomes, tiny subcellular particles containing proteolytic enzymes.[1] These enzymes attack their host cell and go on to damage or destroy other cells.[2] The resulting tissue damage may not readily repair itself even if the shock patient survives.

When administered in conjunction with standard therapeutic measures, Solu-Medrol exerts a protective effect on the lung and improves the patient's chance of survival.

Prescribing information on following page

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STEROID RESEARCH

lament, "Why did everything eventually go wrong when the operation went so well?". They have produced a work which will be warmly welcomed by all with an interest in gastroenterology and with enthusiasm by the practising surgeon.

The book is divided into three sections headed, respectively: postgastrectomy complications, malfunction of the small intestine after surgery, and disorders of function after colon surgery. Each section is introduced by a review of the normal physiology and function, and in succeeding chapters the way in which surgery may disturb function is discussed.

In the first section there is a detailed review of the motor and secretory functions of the stomach together with the pathophysiology of peptic ulceration. Interspersed in this section are interesting items of information on the reduction in intestinal inhibition of gastric secretion following truncal vagotomy and the role of serotonin and enterogastrone in intestinal inhibition of gastic secretion. There is an intriguing hypothesis about gastric ulcer patients—those with raised serum gastrin levels are likely to have either structural or functional obstruction to gastric emptying and require relief of obstruction, while in the rest abolition of secretion only may be sufficient.

In the sections that follow the causes of early and late sequelae of gastric surgery and vagotomy are discussed with recommendations on the best way to recognize and manage these problems.

Probably the most impressive section, and the longest, is that dealing with malfunction of the small intestine following surgery. A masterly review of the modern concepts of the mechanism of digestion and absorption from the small intestine is followed by a detailed account of how these mechanisms become deranged by surgical procedures. Of more than passing interest to all concerned in patient management will be the findings that transport sites for vitamin B_{12} may develop in the proximal remnant of intestine following resection of ileum; that a jejunal remnant may develop the capacity actively to transport conjugated bile salts; that the ileum and colon have the capacity to assume the work-load formerly subserved by the jejunum; and the observation that both gastric emptying and intestinal propagation are accelerated after distal but not proximal resection of small bowel.

A section is devoted to the metabolic problems resulting from massive resections of the small bowel and this is followed by a lengthy account of the care of such patients. There are useful hints about the manipulation of the digestive/absorptive mechanisms in the remaining small bowel to promote adequate caloric intake, and the optimal time for wean-

(Continued on page 354)

THE CANADIAN JOURNAL OF SURGERY
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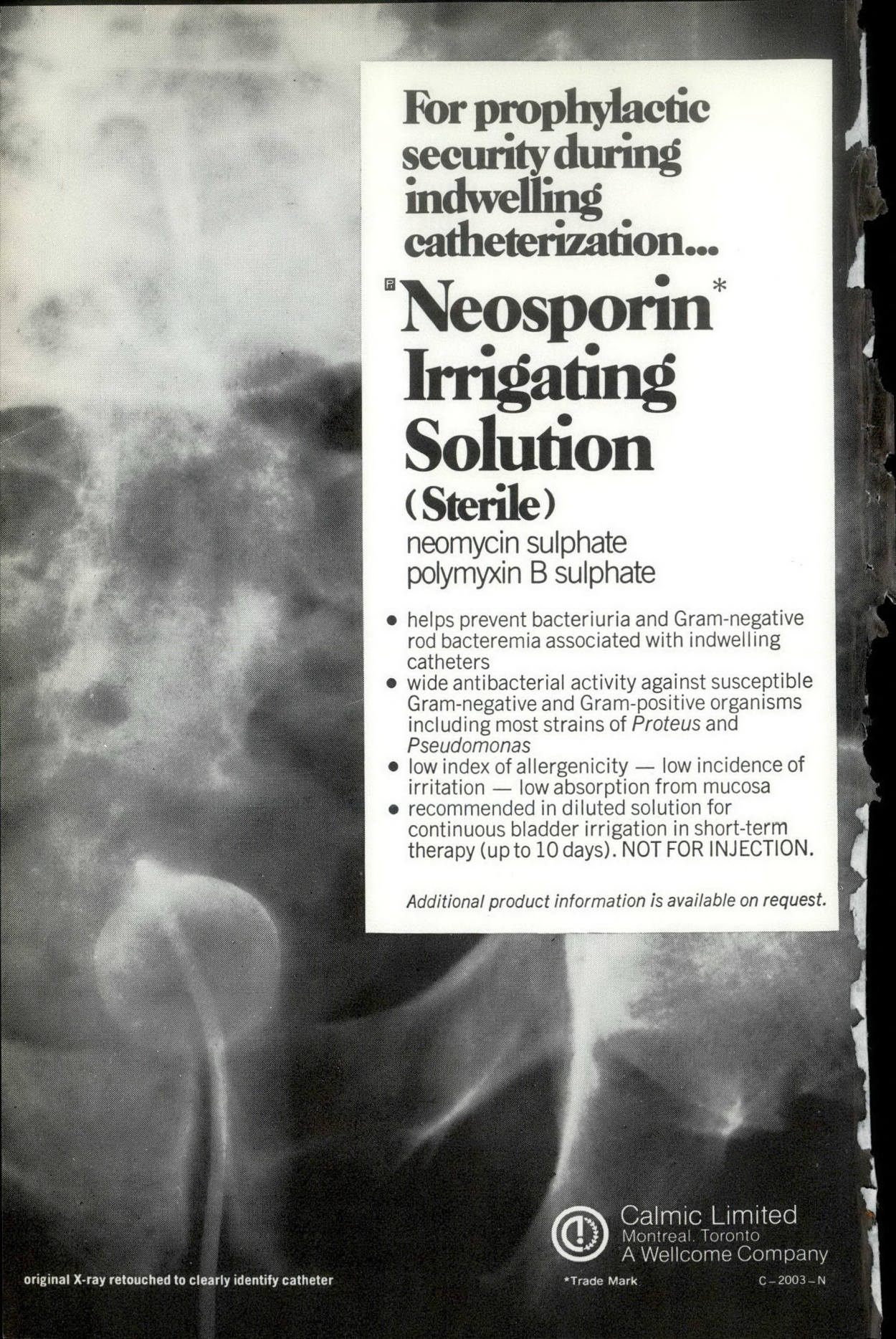

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