SURGERY IN THE NEWBORN*

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Fewer than 50 years have elapsed since it first became apparent that sick children require the care of trained paediatricians. Today, paediatrics is so well established that no one any longer questions the necessity of having a capable paediatrician in charge of a sick child. Paediatric surgery has lagged behind.[28,62] For many years it was generally assumed that an infant was merely a small person to whom the principles of adult surgery could be applied. As long as a smaller incision was made, and smaller instruments were used, the requirements were fulfilled.[42]

Thirty years ago Sir Lancelot Barrington Ward,[2] of the Great Ormond Street Hospital, most aptly remarked: 'The adult may safely be treated as a child, but the converse can lead to disaster'. This is well illustrated by a recent survey made by Rickham[53] of all infants born with urgent surgical conditions in the Liverpool area during 1949. He found that during that year 75 neonates with urgent surgical conditions were admitted to 14 hospitals, where they were treated by various general surgeons. The mortality rate was 72%. Here in Cape Town before 1952 the mortality in neonates from conditions such as tracheo-oesophageal fistula, diaphragmatic hernia and intestinal atresia was 100%. Until that time our custom, in common with that of many others, was to rely on the paediatrician to make the diagnosis, prepare the child for operation, and take charge of the post-operative care. The surgical consultant, who was called in for the operation only, was used merely as a technician or craftsman.[28] The poor results speak for themselves.

Neonatal surgical emergencies are not common and few general surgeons see more than a couple of cases during their

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professional lifetime. This type of work, therefore, can occupy no more than a fraction of the general surgeon's time and he cannot expect to become proficient in the entire care of the infant. However, the field is broad enough to maintain the interest of a paediatric surgeon and difficult enough to demand his utmost in skill and ingenuity.[46]

Approximately 4% of infants are born with extensive deformities.[47] Only a few—a small fraction of 1%—cannot be saved by surgery; the remainder are all amenable to skilled surgical treatment. Rickham[53] estimates the incidence of urgent surgical conditions in the neonatal period at 2 per 1,000 live births. During the past 9 years 406 cases have been treated in our unit (Fig. 1). These cases have come from the Greater Cape Town area, where the number of live births is approximately 18,000 per year, i.e. 162,000 during the 9-year period, which gives an incidence of 2·5 'surgical cases' per 1,000 live births. However, when it is considered that over 300,000 infants are born in South Africa each year, it should be obvious that the total number of neonatal surgical emergencies in the country as a whole is far from insignificant.

It is true that the numbers are comparatively small. Nevertheless, these malformations still constitute the 'hard core' of neonatal mortality.[38] Fig. 1 reflects the type of

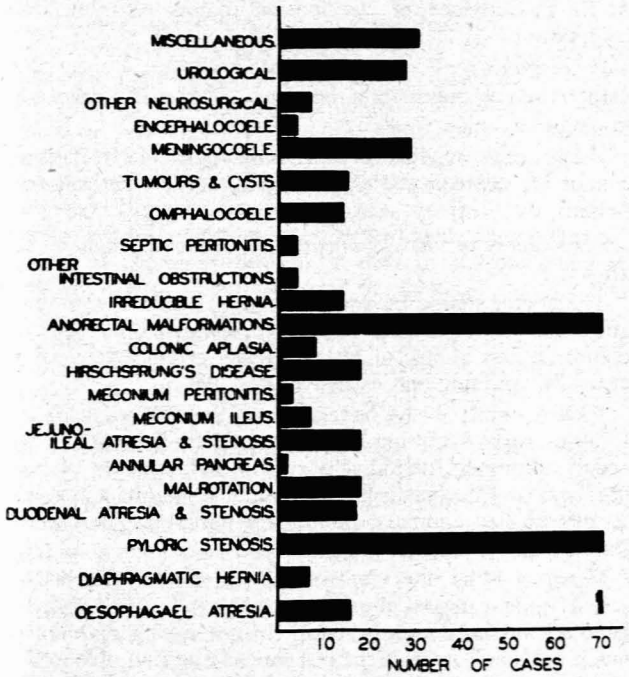

Fig. . Neonatal surgical emergencies seen at the teaching hospitals of the University of Cape Town, 1952 onwards.

problem encountered. Most of these anomalies are inevitably fatal if untreated but are today amenable to surgical correction.[4,25] This applies particularly to 5 groups, viz. oesophageal atresia (16 cases), diaphragmatic hernia (8 cases), intestinal obstructions (109 cases), anorectal malformations (71 cases) and omphaloceles (14 cases).

Recent advances in the surgery of infancy and childhood have reduced the total mortality rate of neonatal surgical emergencies treated in special centres to 20% and less, and in many of the babies successful surgery has resulted in a normal child with an expectancy of life which is far greater than that found in any other branch of surgery.[18,19,47,51,53,62] Our results in the 5 important groups are given in Table I.

TABLE I. MORTALITY OF COMMON NEONATAL SURGICAL EMERGENCIES: CAPE TOWN UNIVERSITY TEACHING HOSPITALS 1952 - 59

Anomaly	*Mortality*
Diaphragmatic hernia	50%
Oesophageal atresia	40%
Intestinal atresia	33%
Omphalocele	20%
Rectal agenesis	5%
Average of above anomalies	20%

It must be emphasized, however, that such a significant reduction in mortality is only possible if all those who are concerned with the care of the newborn infant are aware of the possibilities, and are on the alert to make the diagnosis sufficiently early for surgery to be successful.[38,62] This is the main justification for a paper of this kind which has nothing original to report.

(A) UNCONTROLLABLE FACTORS

Before discussing the management of newborn infants suffering from surgical ailments I wish to draw attention to 2 factors which affect the results adversely and which are largely beyond our control. These are (1) the tendency for congenital anomalies to be multiple, and (2) prematurity.[4,18]

1. *Multiple Congenital Abnormalities*

Multiple anomalies were present in nearly 25% of our cases and contributed to at least one-third of the deaths. The presence of multiple deformities in the same infant is no doubt related to the genesis of malformations in general and points to an aetiological factor operating during the very early months of pregnancy and affecting many systems at a stage when they are undergoing active differentiation.[35,60] Their presence may not be immediately apparent and the attending doctor must therefore be alert to the possibility and search for unsuspected anomalies,[55] including, for instance, the following:

(*a*) Oesophageal atresia is often associated with cardiovascular, anorectal and intestinal anomalies.

(*b*) Diaphragmatic hernia was accompanied by intestinal malrotation in almost 50% of our cases.

(*c*) Duodenal atresia is commonly found in mongols. In previous articles we reported that about one-third of babies presenting with duodenal occlusions were mongols,[5,31,32] and that other intestinal atresias were multiple in 10% of cases.[32,34,35]

(*d*) Rectal agenesis was associated with vertebral malformations in 50% of our cases, urinary anomalies in 60%, and other deformities, especially of the oesophagus and heart, in 65%.

(*e*) In omphalocele there is a higher incidence of associated malformations than in any other congenital anomaly.[47]

2. *Prematurity*

In our series of neonatal surgical emergencies almost 50% of the infants were premature. This alone is an important cause of death in newborn infants,[18] and of our cases who succumbed after operation nearly two-thirds weighed less than 5 lb.

Paediatricians in many countries have achieved remarkable success in lowering the neonatal mortality by tackling the problem of the care of the premature baby on a national

basis.[53] Surgeons can lower the mortality in this group even further by being thoroughly familiar with the care of the premature infant[18] and modifying the corrective surgical procedures in such a way that only the bare minimum for immediate survival is done in the first place.[18,25]

(B) CONTROLLABLE FACTORS

There are obviously many and varied factors which make for success in neonatal surgery and it is difficult to single out any particular one; but, in short, the secret of success lies in scrupulous attention to detail. The surgical infant requires service 24 hours a day, 60 minutes an hour and 60 seconds a minute. Just that extra little bit of attention may tip the scale in the right direction. Whether this attention be early diagnosis; a small trick in surgical technique; the judicious use of blood or plasma; aspiration of pharyngeal secretions; irrigation of a blocked nasogastric tube; changing of the infant's position regularly; or some other minor detail; it is the sum total of these procedures that saves a tottering case.[36]

Only the most important factors can be discussed and I shall deal with them in chronological sequence rather than on a basis of priority by importance:

1. Early Diagnosis

Time is an important and often a vital factor in all disease[6] and nowhere is this better illustrated than in neonatal surgical emergencies. Thus, in an analysis of intestinal atresia and stenosis treated at Great Ormond Street Hospital up to 1951, I found that no infant operated upon after the 6th day of life

TABLE II. AGE AT OPERATION IN 39 URGENT CASES

Age (hours)	*No. of Cases*	*Deaths*	*Mortality*
Under 24	5	1	20%
24 - 48	7	3	43%
48 - 72	8	4	50%
72 - 96	5	3	60%
96 - 120	5	3	60%
120 - 144	3	2	67%
Over 144	6	5	83%

survived.[33] There was also a close correlation between the age of the infant at operation and the mortality. In the present series there has been a similar correlation; and in 39 urgent cases that I reviewed in 1954 the mortality rose from 20% in those operated on in the 1st day of life to 83% in those operated on after the 6th day[31] (Table II).

If he is to have the opportunity of saving even a few valuable lives the surgeon is absolutely dependent upon those who have the responsibility of the initial care of the newborn.[38] This applies *par excellence* to infants suffering from congenital diaphragmatic hernia and ruptured omphalocele. In oesophageal atresia, the various intestinal obstructions, and rectal agenesis, the urgency of early diagnosis is almost as great.[19,62]

Prompt diagnosis requires no particular diagnostic acumen or skill. It merely demands a few elementary requisites:

(*a*) *Recognition of Prenatal Warning Signs*

The practitioner, obstetrician and paediatrician should be aware of the fact that congenital anomalies tend to occur with a high degree of frequency in cases of hydramnios, prematurity and multiple pregnancy.[21,32] In such cases a special effort should be made to exclude the presence of any serious abnormality, particularly oesophageal and duodenal atresia.

(*b*) *Thorough General Examination of the Infant at Birth*

Denis Browne has said that the baby at birth should receive the same attention as is usually bestowed upon a new motor car or a favourite racehorse. There is no excuse for not examining the newborn infant thoroughly from head to foot before it is bound and swathed in diapers, binders, ribbons, booties and other impedimenta which render examination virtually impossible.[47]

Inspection of the naked infant on a table is all that is required to make a diagnosis of several serious anomalies, e.g. omphalocele, meningocele, encephalocele, extrophy, and gross external deformities. Visual examination of the abdomen may reveal the distension of intestinal obstruction or the scaphoid abdominal wall of diaphragmatic hernia.[4] In the latter, simple inspection of the chest may be all that is required to detect asymmetrical expansion of the two sides and displacement of the mediastinum. A glance at the anogenital area will serve to make a diagnosis in all but the rarest of anorectal malformations and may even reveal the presence of an unsuspected strangulated hernia.

Palpation may lead to the discovery of distended intestinal loops or abnormal abdominal masses, confirm displacement of the heart in suspected diaphragmatic hernia, or even detect the absence of the femoral pulses resulting from coarctation.[47]

Percussion may elicit a tympanitic note over a chest filled with bowel, or dullness in the flanks of the abdomen containing free fluid.

Auscultation may be as rewarding, particularly if bowel sounds are heard in the chest or gross cardiac murmurs are present.

(*c*) *Awareness of the Significance of Cyanosis, Vomiting and Drooling*

The doctor should be aware of certain ominous symptoms and signs which will enable him to diagnose most internal malformations almost at birth. Here I refer particularly to cyanosis, vomiting and excessive drooling.

Cyanosis must always be regarded with grave suspicion.[19,62] It is an early symptom of diaphragmatic hernia. It will occur, admittedly periodically, within a few hours of birth in all cases of oesophageal atresia, and it may be a sign of a serious cardiac anomaly, pulmonary pathology, or cerebral trauma.

Vomiting is as important.[19,62] Prof. Findlay Ford[16] has stated quite categorically that a newborn infant properly handled and fed does not vomit. In my humble opinion too much emphasis is often placed on the question of handling and feeding with resultant disregard of the sinister symptom of vomiting. Vomiting that proceeds throughout the first day of life requires urgent investigation. Vomiting that is bile-stained is very serious, and should be regarded as due to intestinal obstruction until disproved.[32,41,51,61]

The production of excessive frothy mucus associated with persistent drooling and bubbly saliva[19,61,62] is another significant although uncommon symptom. Any infant who shows difficulty in handling his pharyngeal mucus should immediately raise the suspicion of oesophageal atresia.[4] The baby is literally blowing bubbles to preserve his life and attempts at feeding may have disastrous consequences, because of regurgitation, aspiration and suffocation.

(*d*) *Digital Rectal Examination*

It is disturbing but true that the diagnosis of an anal membrane is usually made by a junior nurse who, in attempting to take the baby's temperature, finds that the thermometer cannot be passed. The moral is a simple one; viz.: Inspection of the perineum may not be enough to diagnose some of the rarer forms of anorectal malformations and 'if you do not put your (little) finger into it, you will put your (big) foot into it'. Digital examination of the rectum may also clarify the diagnosis of neonatal Hirschsprung's disease.[62]

(*e*) *The Non-urological Use of the Urinary Catheter*

In some cases of Hirschsprung's disease and some anorectal malformations it may be necessary to pass a rectal catheter to make the diagnosis. This should be routine in all patients with abdominal distension associated with a delay in the passage of meconium.

Another special manoeuvre that is sometimes required is to pass a catheter into the oesophagus. This should be done whenever there is persistent accumulation of frothy mucus in the pharynx and also in all cases presenting with rectal anomalies, because of the frequent association of anorectal and oesophageal malformations. A firm catheter, size 8 - 10 (Jacques type) should be used—softer catheters tend to curl up in a blind oesophageal pouch and may be misleading.[19]

(*f*) *Radiological Examination—its Uses and Abuses*

Confirmation of the diagnosis usually requires nothing more than plain X-rays of the chest and abdomen.[19,62] Such investigation should, however, be deferred until the infant has been transferred to a special paediatric centre. This will not only save invaluable time, but will also avoid unnecessary mistakes, which are only too frequently made by those who are unaccustomed to radiography in small infants.[46,56] A special word of warning must be sounded about the grave danger of giving barium by mouth to newborn infants, especially those suffering from oesophageal or intestinal obstruction. The barium is readily regurgitated or vomited and then aspirated into the lungs, with the development of serious atelectasis and bronchopneumonia.[32] If any X-rays have inadvisedly been taken they must be sent with the child to hospital.

It has been stated that delay in diagnosing these congenital defects implies either professional ignorance or poorly managed neonatal nursing. The following facts may thus be somewhat revealing:

(*a*) Less than one-third of our patients were diagnosed during the first 48 hours of life.

(*b*) One of our cases of oesophageal atresia was 9 days old on admission, and another, born in a maternity institution, 7 days old.

(*c*) A baby suffering from a large diaphragmatic hernia with intense respiratory distress was referred to us from another maternity institution 48 hours after birth with a diagnosis of staphylococcal pneumonia.

(*d*) Only 5 of our cases of intestinal obstruction were diagnosed by the 2nd day of life, and 27% were more than 5 days old on admission.

(*e*) Omphaloceles are usually recognized early (because they get in the way when the cord has to be tied), but even with them mistakes are made. One of our cases had his hernia ruptured by a paediatrician who failed to recognize the anomaly and inquisitively poked his finger right through the sac.

(*f*) Only one of our cases of imperforate anal membrane was correctly diagnosed before admission to hospital and several cases with obvious anorectal malformations were referred to us on the 4th or 5th days of life!

The attendant who accepts the care of newborn infants should be alert and constantly on guard, accustomed to watching normal activity and immediately suspicious of any alterations in behaviour which could mean trouble ahead. This applies not only to every paediatrician, obstetrician and general practitioner, but also to midwives and medical students who may bring these unfortunate babies into the world. All medical and nursing personnel who deal with newborn infants should be trained in the recognition and first-aid treatment of neonatal surgical emergencies.[22]

2. Concentration of the Patients in a Central Paediatric Surgical Unit

The desirability of treating surgically-ill infants in a special unit is obvious. Today it is not only desirable but essential[29,53] and merits some discussion:

(*a*) *Transport to the Centre*

The responsibility of early and safe transport of the infant to a proper centre rests upon the general practitioner, obstetrician and paediatrician.[3,15] Having made a prompt diagnosis it is then their duty to act with dispatch, because the salvage rate diminishes with every passing hour.

There is an idea prevailing that neonates do not tolerate transport. This is a misconception.[3] Newborn babies, having successfully survived a journey lasting many hours through the vaginal canal, where they have been pushed from behind, squeezed from the sides, and often pulled from the front, will tolerate a comfortable car trip or air flight with ease and safety. There is thus no excuse for not getting the infant to a special hospital, no matter how remote he may be from such a centre.[3,15] It is certainly far wiser to transfer the baby to a special institution than to attempt treatment, usually inexpert and doomed to failure, in the home village or town.

Ideally, the infant should be transported in a portable incubator at 85° to 88°F,[15] but this is often not possible. In most cases it will suffice to have the baby in a carry-cot, or simply on the lap and wrapped up in blankets. It is desirable that oxygen should be given, especially during air travel, and this is easily achieved by means of a simple face cone.

During transport the infant should be nursed lying flat or on its side and disturbed as little as possible. No feeds, not even water, should be given by mouth and intravenous or subcutaneous fluids are seldom necessary—it is perfectly safe, and indeed advisable, to give no fluids at all for 36 - 48 hours.

It is usually necessary to keep the nose, mouth and pharynx clear of secretions by regular aspiration (every quarter to half hour, if necessary) with a Queen Charlotte's mucus extractor. If there is any tendency to vomiting, a catheter (size 8F) should be passed into the stomach, which is then emptied regularly with an ordinary 20 c.c. syringe.

In certain cases special precautions have to be taken; for example, omphaloceles, meningoceles and encephaloceles should be covered with sponges soaked in mild antiseptic, such as cetavlon or hibitane and protected from trauma. If there is a risk of infection, penicillin (30,000 units) should be given and it is advisable to administer 2 mg. of vitamin

K in infants who are likely to require surgery. Full details of all treatment given must be sent with the child.

It is obvious that the infant should be accompanied by a competent nurse and/or medical attendant, and it is a good thing for the father to go along as well to fill in the necessary admission forms and sign consent for operation.[3]

(b) Locality of the Centre

These infants can be properly cared for only in a special

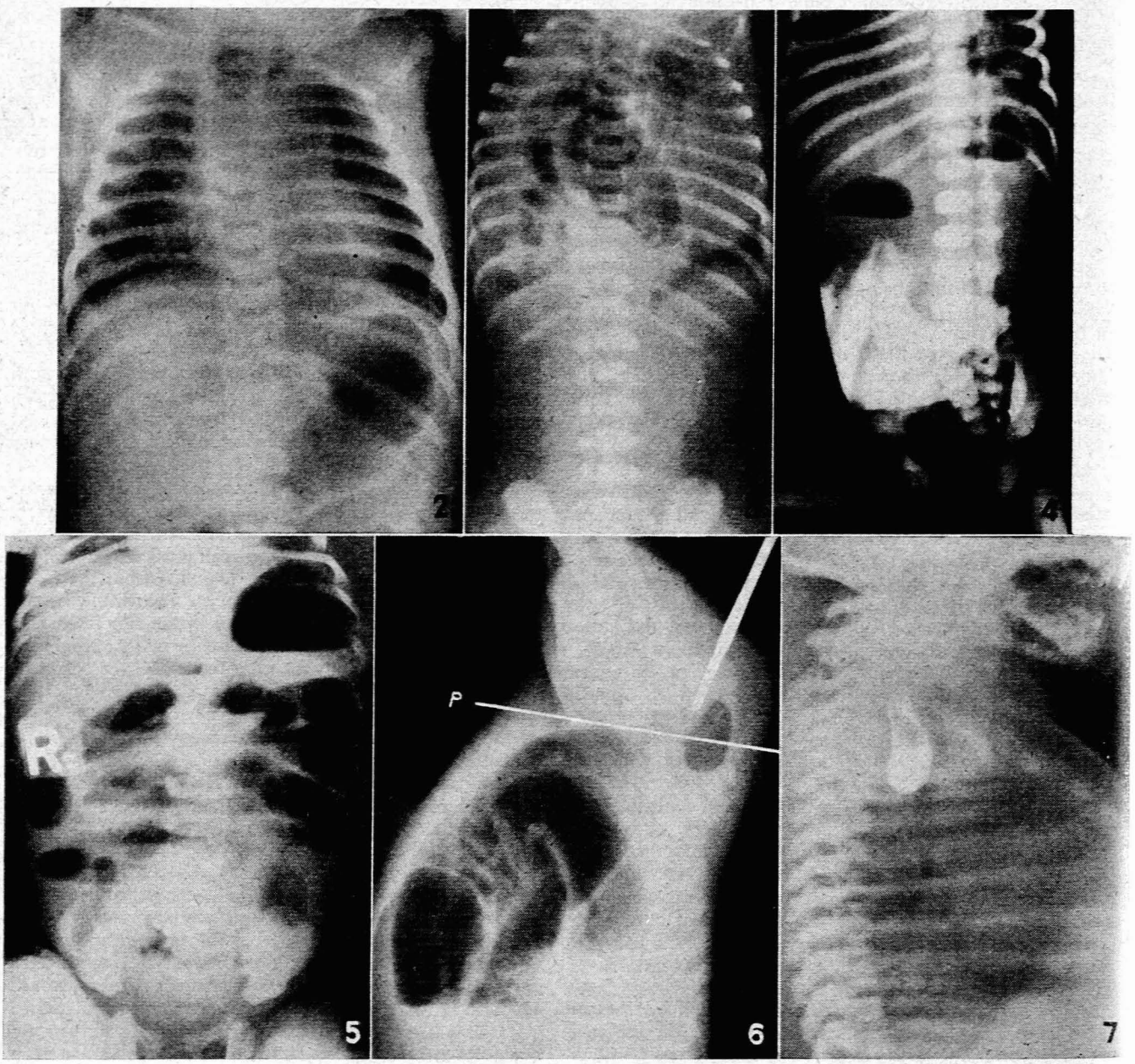

Fig. 2. Plain X-ray of a baby suffering from oesophageal atresia. Note the gas in the upper blind pouch. The presence of gas in the stomach indicates that a fistula exists between the lower oesophageal segment and the trachea.

Fig. 3. Plain X-ray of a baby suffering from a large left postero-lateral diaphragmatic hernia (Bochdalek type). The left hemithorax contains gas-filled intestinal loops, the heart is displaced to the right, and the abdomen contains hardly any gas shadows.

Fig. 4. Plain X-ray of a baby suffering from duodenal atresia. Note the characteristic 'twin fluid levels' with no gas in the intestine beyond the duodenum.

Fig. 5. Plain X-ray of a baby suffering from ileal atresia, showing diagnostic multiple fluid levels.

Fig. 6. Plain X-ray of a baby suffering from an imperforate anal membrane. The film was taken with the child in the inverted position and a thermometer was placed into the blind anal canal. Note that the thermometer impinges on the gas shadow in the rectum, indicating the presence of a membrane.

Fig. 7. X-ray of a baby suffering from oesophageal atresia. Lipiodol (1 ml.) was instilled into the upper blind oesophageal pouch.

children's institution which has a separate and unified area, adapted to, and staffed for, surgical care.[18,29,36] Only in large children's hospitals will it be possible to find a team with the necessary training and experience. No surgeon can undertake this type of surgery with any hope of success unless he has the close cooperation of experienced anaesthetists, paediatricians, biochemists, pathologists, radiologists and surgical colleagues, as well as willing and devoted residents and a nursing staff specially trained in the nursing of small babies.[42,43,47]

Since neonatal surgical emergencies are relatively infrequent, and since efficiency and skill can be obtained only by intelligent repetition,[46] paediatric surgical units should serve a large population. Only in this way can the team acquire the experience necessary to get satisfactory results.

(*c*) *Personnel*

Modern practice in the surgery of infants and children demands that the surgeon who operates on a child, and particularly on a newborn infant, must be thoroughly familiar with all the phases of pre- and post-operative care.[7,19,28,40,46,62] He should be conversant with the factors of early development, both pre- and postnatal.[28,36] He should have a deeply ingrained affection for children; he should be able to attend to feeding problems; he should have an accurate knowledge of electrolyte, fluid and other physiological requirements; he should know how to act with dispatch in times of emergency and he should have the 'caressing touch', so important when handling the delicate and fragile tissues of the infant.[46] In short, his responsibility is the total care of the child and the surgeon alone must assume the full responsibility.[19,46] In this type of surgery, more than in any other branch of surgery, there is no longer room for the occasional operator, who visits the hospital on a rotating scheme or perhaps only when he feels so inclined.[23,62]

It is not suggested that *all* children's surgery should be done by children's surgeons, but it must be pointed out that in infants, especially newborn infants, the mortality and morbidity of surgical procedures are greatly reduced when the patients become the sole concern of a specially trained surgeon instead of part of a much broader field of surgical endeavour.[19,23,27,39] Today in the USA and the UK the medical profession is seeking, and parents are demanding, that infants should receive the same expert care from surgeons that paediatricians offer for their medical ills.[47]

It must be emphasized, however, that one man alone cannot expect to manage by himself the newborn infant who has had an operation. He must be assisted by a team consisting in the first place of residents who are already seasoned trainee-surgeons and in addition desirous of extending their training

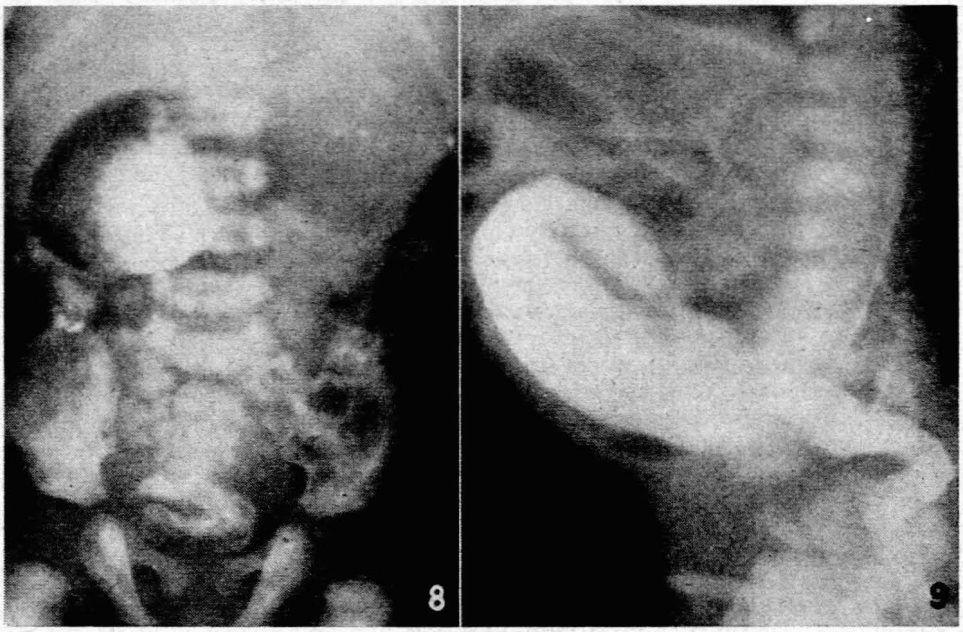

Fig. 8. X-ray of a baby suffering from severe duodenal obstruction due to malrotation of the midgut. The infant was given lipiodol, which is almost completely held up in the large, dilated duodenum.

Fig. 9. Barium-enema X-ray of a newborn infant suffering from Hirschsprung's disease, showing the typical 'narrow segment' with dilated colon proximally.

into this field. These men should be alert enough to recognize even the slightest change in the infant's condition. They should be adept at setting up intravenous infusions. They should be able to use a laryngoscope and pass an endotracheal tube, and they should be capable of dealing efficiently with all the numerous emergencies that occur so suddenly and dramatically in a newborn baby. Above all, they should have a devotion to duty which will render their trying task of acting as round-the-clock watchmen a pleasure and not an arduous duty.

In addition, the absolute necessity of having nursing staff skilled in the care of this type of patient is obvious.[17] To obtain the best results and avoid catastrophe in the surgical problems of early life, special training in this field by all concerned is required. It is indeed a pity that the South African Nursing Council does not recognize this basic fact and that the Red Cross Children's Hospital still has to cope with inadequate numbers of trained sisters helped by nurse aids.

3. Adequate Pre-operative Management

(*a*) *Minimal Interference*

The tolerance of newborn babies for corrective surgery is remarkably good, provided it has not been weakened by delay in diagnosis or over-enthusiastic investigation and treatment.[4] The newborn baby is acclimatized to the protected existence of intra-uterine life, and the less he is handled the better.[18,26] A rigid 'hands off' policy, except for essential procedures, should therefore be enforced.

Elaborate diagnostic procedures are seldom necessary. Extensive haematological and biochemical determinations

are not required, and may be misleading. Over-treatment may be more disastrous than under-treatment. C. A. Smith's words[58] are particularly applicable to the management of newborn infants undergoing surgery: 'We should approach our newborn patients gently, watchfully and, above all, repeatedly, but always consider whether what we observe may not be within normal limits for them. If we ask ourselves, first, may this not be acceptable neonatal behaviour and, second, am I sure that I can correct it any better than the infant can, if left to himself, we would be making what seems to me a proper approach to the newborn infant'.

Plain films of the chest and abdomen (erect and supine) are usually all that is required to make a diagnosis of oesophageal atresia (Fig. 2), diaphragmatic hernia (Fig. 3), duodenal occlusion (Fig. 4) and other intestinal obstructions (Fig. 5). In cases of suspected rectal agenesis, imperforate anal membrane, or imperforate anus, lateral films of the baby in the inverted position are of value (Fig. 6).

Contrast media by mouth may be required in cases of oesophageal atresia and incomplete intestinal obstruction. In the former, 0·5 - 1 ml. of lipiodol is injected into the upper blind pouch through the catheter that has been previously passed (Fig. 7). In the latter, lipiodol is far safer, although admittedly less satisfactory, than thin barium (Fig. 8).

Lipiodol or barium enema examination is occasionally helpful in cases of intestinal obstruction, to differentiate between atresia, meconium retention, and neonatal Hirschsprung's disease[55] (Fig. 9).

(*b*) *Constant Observation*

The status of a surgically-ill newborn infant sometimes changes drastically in a matter of seconds. The need for constant observation by an experienced person, therefore, cannot be over-emphasized.[18] We feel so strongly about this that all our cases are 'specialled', not only by the nurse in charge, but also by a senior registrar who is competent to deal with respiratory and other emergencies as soon as they occur. Early recognition of any 'change for the worse', and prompt action in correcting its course, is often life-saving. There is little doubt that our salvage rate has been almost doubled simply by observance of this rule; such professional supervision is the only way of preventing unnecessary complications and death.

(*c*) *Isolation and Control of the Infant's Environment*

Newborn infants are susceptible to infection, tend to have an immature heat-regulating mechanism, and have a limited respiratory reserve.[18,58] Susceptibility to infection is related to their immature immune mechanisms and lack of antibodies. Protection from bacteria is, therefore, of vital importance.

Premature infants, in particular, tend to cool down quickly,[19,54,63] and many of our cases, especially those who had been transported, had very low body temperatures by the time that they were admitted to hospital. Excessive cooling carries the risk of sclerema, and it has been shown that the survival rate of premature babies can be increased by reducing their heat loss during the first 5 days of life. Heat loss can be reduced not only by increasing the environmental temperature but also by increasing the humidity to 80 - 90%.[63]

Another important factor which affects survival rate is the limited respiratory reserve of newborn infants.[19,44,58] Their breathing depends to a large extent on abdominal respiratory movements and is therefore seriously reduced by abdominal distension. Furthermore, the respiratory reserve tends to be reduced even further by the presence of atelectasis and tenacious pharyngeal and tracheal secretions blocking the airways.

A modern incubator is therefore absolutely essential for the care of neonates requiring surgery.[4] In America the Isolette type is generally used; we use the Dräger type (Fig. 10). Not only does it isolate the infant and thereby lessen the risk of cross-infection, but it also allows him to be nursed naked without being exposed to draughts and sudden changes of temperature. At the same time, the plexiglass construction allows constant observation of the infant without any disturbance. The modern incubator allows for regulation of heat, oxygen supply and extra humidity, all of which are vitally important in the care of these infants. (Rickham,[66] of Liverpool, has devised a special surgical incubator with facilities for weighing, ready access to the patient's head, inlets for intravenous and other tubing, etc.).

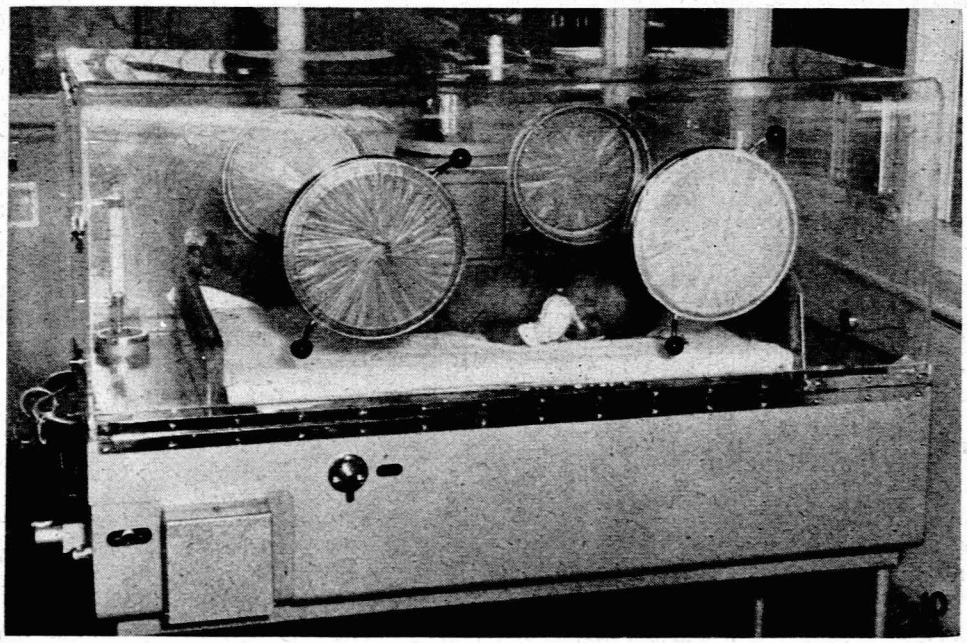

Fig. 10. The type of incubator used for newborn infants submitted to surgery. See text for details.

Any drop in temperature must be immediately corrected by keeping the incubator temperature at 90° - 95°F. Thereafter the incubator should be kept at about 85°F and the baby allowed to establish his own temperature level (97°F).[19] The

humidity should be increased to 80 - 90% to reduce loss of heat, to lessen the tenacity of pharyngeal and tracheal secretions, to loosen plugs of inspissated mucus, and to reduce insensible water loss.

Additional oxygen should be supplied to assist respiration. In general, however, the concentration should not exceed 40% because of the risk of retrolental fibroplasia.

(*d*) *Prevention of Suffocation*

One of the greatest dangers to a newborn infant who is suffering from an obstructive lesion of the alimentary tract is inhalation of vomitus and secretions. It is therefore most important to clear the mouth and pharynx by suction whenever necessary. This should not be overdone, however, because too frequent irritation of the mucous membrane by the aspiration catheter will stimulate increased secretions and provoke oedema. As a rule it is unnecessary to suck out the mouth and pharynx more often than every half to one hour (see also under 'post-operative care').

(*e*) *Gastro-intestinal Decompression*

Distension of the intestinal tract should be prevented as far as possible.[4,18,19,62] The infant with oesophageal atresia should have a catheter with a single hole at its tip placed into the upper blind pouch, and this should be aspirated at quarter-hourly to half-hourly intervals to prevent overflow and aspiration of secretions into the trachea. All other infants should have a paediatric-sized plastic nasogastric tube (or a multi-holed number-8F urethral catheter) passed into the stomach, and constant siphonage with intermittent hourly suction applied (Fig. 11). Longer tubes which extend beyond the pylorus are difficult to pass and demand too much handling of the infant to justify their use.

In some centres pre-operative gastrostomy under local anaesthesia is often performed to facilitate gastro-intestinal decompression, especially in cases of oesophageal atresia.[18,34,62] Whether this should be introduced as a routine measure is a debatable point.

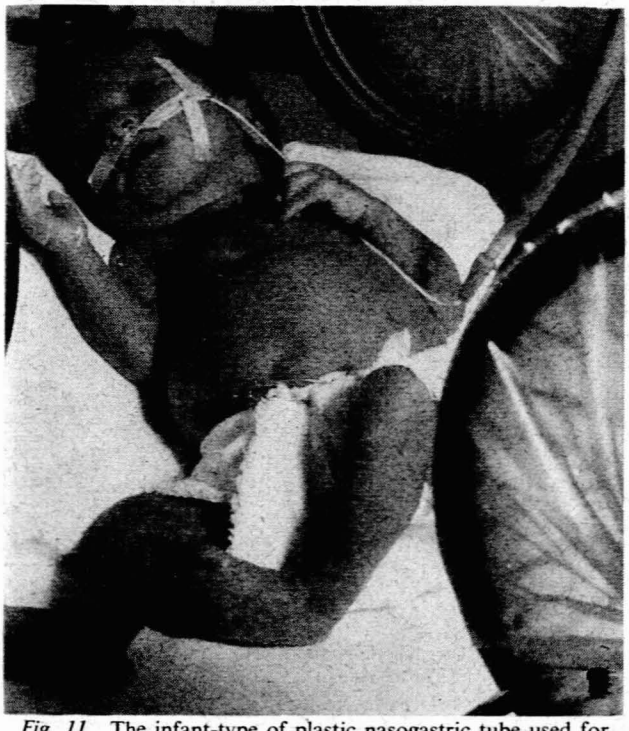

Fig. 11. The infant-type of plastic nasogastric tube used for gastro-intestinal decompression. This is used for *all* cases undergoing surgery and is passed before the child is taken to the operating theatre.

(*f*) *Hydration*

Over-hydration used to be a common cause of death in newborn babies suffering from surgical lesions,[18,19,23,52] and this is probably still so outside special paediatric surgical centres. Surgeons who are not constantly dealing with small babies fail to appreciate that the newborn infant's blood volume is only 40 ml. per lb.[19,30] It is therefore not realized that an intravenous infusion of 40 ml. in a 5 lb. baby is equivalent to an infusion of 1 litre in an adult. The paediatrician, although familiar with this aspect of the problem, is accustomed to dealing with severely dehydrated patients, and is therefore also inclined to give too much fluid.[26]

In recent years paediatric surgeons have aimed at keeping their patients 'on the dry side'.[4,23,52,54,64] This has probably been overdone,[64] particularly in some centres where the babies are kept absolutely dry (i.e. no pre-operative water or electrolytes are given). In this connection it should be noted that infants have a relatively larger surface area per unit of weight than adults have.[58] Loss of fluid may therefore occur rapidly and water deprivation may lead to profound dehydration in a very short time. It is generally agreed, however, that the newborn infant withstands water deprivation extremely well.[1,54,58] The normal newborn infant has excess body water and a large loss of weight, up to 10% of birth weight, is a constant feature of the first few days of life.[63] Premature infants may lose as much as 20% of their birth weight without apparent harm.[63]

Our present practice is aimed not so much at 'keeping the infant dry', as at 'preventing the infant from becoming moist'.[11] Where the diagnosis has been made within 48 hours and there have not been excessive extrarenal losses of fluid by vomiting, we often give *no* pre-operative fluids, for instance, in infants with oesophageal atresia, diaphragmatic hernia, and omphalocele.

In other cases fluids must be given, because it is far simpler and much safer to rehydrate the infant pre-operatively than after surgery. In these cases the degree of dehydration is evaluated on the weight loss since birth (if the birth weight is known) and on clinical signs such as failure to void urine, dry skin, and sunken fontanelles. As regards the clinical appraisal, a reliable working rule is to regard mild dehydration as equivalent to 5% of body weight and severe dehydration as equivalent to 10% (i.e. 20 - 30 ml. and 40 - 60 ml. per pound respectively). Half the calculated amount of fluid may be given at once; a rate of 60 - 80 ml. per hour (10 to 13 drops per minute) is a safe upper limit. The rest is spread over the remainder of 24 hours.

Assessment of the adequacy of rehydration depends upon repeated clinical examinations during administration of the fluid.[1,19,62] The restoration and maintenance of an adequate urinary output are valuable criteria.[62,64] We collect the urine as far as possible (Fig. 12) and hesitate to submit an infant to surgery until adequate urinary excretion has been restored. If urine is passed freely before the prescribed volume has been given a change is made to daily maintenance requirements.

The type of fluid to be given depends upon the cause of the dehydration. In general, half-strength Darrow's solution is

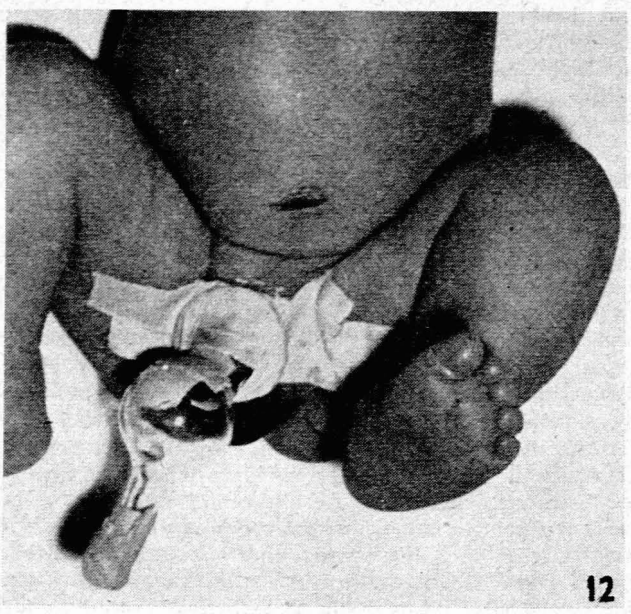

Fig. 12. A method of collecting urine in male infants. A tube is connected to this apparatus and led to a measuring bottle.

safe and adequate. In cases of oesophageal atresia and omphalocele, where the losses are mainly insensible, no electrolytes need be given—we usually administer only 5% dextrose in water. In pyloric stenosis, where large quantities of sodium chloride are lost, half-normal saline should be used, but potassium may have to be added. When dehydration due to acute loss of water and sodium chloride is severe, there is a great risk of acidosis and the surgeon should be ready to give a rapid infusion of saline.[63] Plasma may be given as part of the replacement fluid (10 ml. per lb.), particularly if a strangulating obstruction is suspected. All fluids are given intravenously—usually into a scalp vein (Fig. 13). Fluids should obviously not be given by mouth, and subcutaneous infusions should be avoided at all costs.

(*g*) *Blood Transfusion*

Pre-operative blood transfusion is rarely necessary, but may be required to restore blood volume in intestinal obstructions. If there is anaemia it should be corrected but the transfusion should not exceed 10 ml. per lb.[62] (This is a safe limit, which will be of appreciable value to an average patient without involving the danger of overloading him. When the haemoglobin concentration is low this amount will raise it by approximately 1 g.%.) Furthermore, blood will almost always be required, and may be life-saving, during the operation. Therefore all newborn infants without exception should have a needle in place before the start of any surgical procedure.[47]

In many centres a 'cut-down' on an ankle vein is preferred,[30] but we have managed very well with scalp and arm vein 'push-ins'. Indeed, we take a pride in the fact that cut-downs, with their attendant risks of phlebitis and infection, are hardly ever necessary in our unit.

It must be remembered that the insertion of a needle or cannula into a vein of a small infant is difficult and requires much experience. Occasionally it takes more time than the operation itself. It is therefore important to curb the temptation to proceed with the operation without a secure, tested needle, or cannula, in a vein.

(*h*) *Antibiotics*

In these days of 'hospital staphylococci' the routine prophylactic use of antibiotics in adults and in children is naturally frowned upon. In neonates, however, who have an immature immunological mechanism and who lack antibodies, the situation is somewhat different.[19] Lengthy surgical procedures carry a grave risk of pulmonary complications which, if aggravated by secondary infection, are often fatal. In certain intestinal obstructions, peritoneal contamination is almost inevitable and may tip the scale against survival. It is, therefore, a wise precaution to use a broad-spectrum antibiotic such as chloromycetin and to commence therapy as soon as possible to provide adequate blood levels at the time of operation.

(*i*) *Vitamins*

Vitamin K in small dosage (not more than 2·5 mg.) is indicated to prevent hypoprothrombinaemia with its attendant risk of bleeding at the time of operation and during the post-operative period. It is unnecessary to give larger doses, which may indeed be dangerous because of the risk of kernicterus.

Other vitamins (B and C in particular) may be added to the intravenous fluids (see under 'post-operative care').

(*j*) *Transportation to the Operating Theatre*

It is essential that there should be no slackening in the

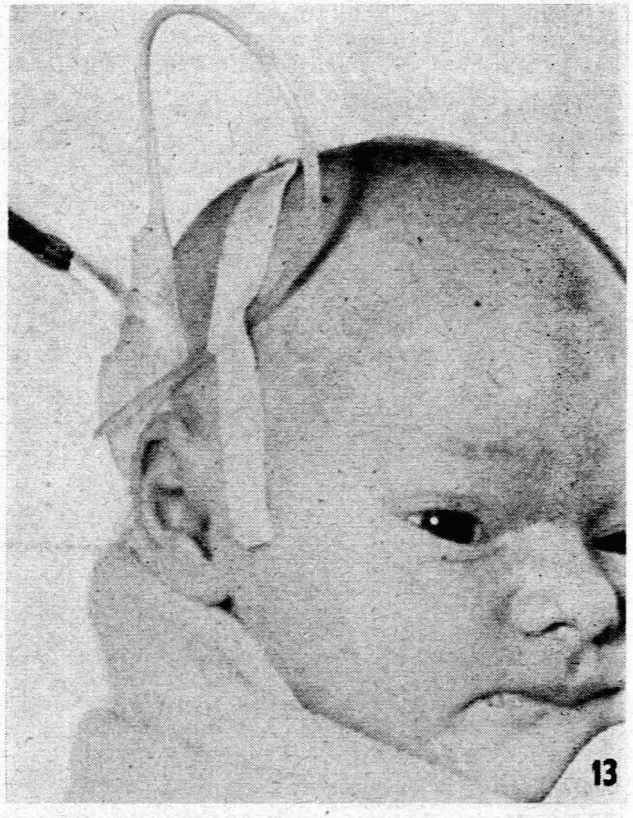

Fig. 13. Intravenous fluids are almost invariably given into a scalp vein. A special needle is used and secured in place with cotton-wool impregnated with nobecutane or collodion and with strapping.

intensive care and constant observation of the infant during his transportation from the ward to the operating theatre.[19] To avoid chilling he should be moved in the incubator and he must be accompanied by the registrar in charge, who should ensure that there is no interference with the intravenous drip and who can attend to any emergency en route.

(To be continued)