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Analysis of the factors in post-operative wound infections at the University of Nebraska Hospital from November 28, 1959 to February 6, 1960

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AN ANALYSIS OF THE FACTORS IN POST OPERATIVE WOUND INFECTIONS AT THE UNIVERSITY OF NEBRASKA HOSPITAL FROM NOVEMBER 28, 1959 TO FEBRUARY 6, 1960

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INTRODUCTION

What is the rate of operative wound infection at the University of Nebraska Hospital? In order to answer this question, I studied 189 patients undergoing operation consecutively from November 26, 1959 thru to February 6, 1960. I found an incidence of 6.5 per cent in "clean operations".

As a corollary to this study, I had to classify operations as clean, potentially contaminated or infected. Also, I became interested in analyzing the causes for wound infection after clean operations. And, finally, I became interested in determining the number of patients in whom bacteremia was found at autopsy to be an important factor contributing to death.

Of the 189 patients studied, 84 had clean operations, 69 had potentially contaminated operations and 36 had infected operations of those cases cultured. Streptococcus hemolytic was most commonly in clean operations, enteric in potentially contaminated operations and a wide variety in infected operations. The presence of pre and post operative antibiotics appeared to contribute to the incidence of infections in "clean" operations. I could demonstrate no relation between the type of suture used, the length of operation, or the habitus of the patient and the incidence of infection. Septicemia or probable septicemia contributed to the death of 30 of 132 patients who came to autopsy in 1959. This was no great change from 1951 when septicemia or probable septicemia contributed to the death of 28 out of 130 patients who came to autopsy.

HISTORY

Microbiology as we know it has a relatively short history. Familiarity i. e. this history helps in understanding the multiplicities involved in preventing or treating operative wound infections. For this reason, I have summarized the following from Leikind "The Surgeon In The Invisible World"[27].

The control of infection should be so routine a part of the surgeons training and so ritualized in it's performance that he can be adjudged guilty of malpractice if he fails to take any necessary step to prevent infection. Yet, only a century ago, infection and death from infection were regarded as unavoidable frequent concomitants of surgical practice.

By the middle of the nineteenth century, surgery seemed to reach an impasse. Of brillant and courageous surgeons there was no death but what did it avail surgeons to operate successfully when they lost so many patients afterwards to infection?

At this time a revolution so far reaching in its consequences occurred that it completely transformed the art of the surgeon. This revolution is generally attributed to the emergence of the Germ Theory of disease and its application in a system of antiseptic surgery, later to be modified to aseptic surgery.

In most popular accounts of the history of surgery, two men are usually mentioned above all others as responsible for this beneficent revolution: Louise Pasteur and Joseph Lister, the first

a chemist, the other a surgeon. In this presentation, however, it is not my intention to repeat a story already well known. What I wish to do is to discuss, from a broader view point, the rise of Microbiology and Immunology and to show how in the course of this development surgery itself was altered; how surgery which seemed to have reached a dead end of futility, was in fact rejuvenated and was able to advance to new heights of achievement in the relief of human suffering and the extension of human life and usefulness.

In the year 1676 a Dutchman named Antony van Leeuwenhoek first saw bacteria and protozoa and thus became the first microbiologist. This discovery raised no special attention and probably Leeuwenhoek himself knew not of the importance of his discovery. No one seemed to notice Leeuwenhoek's publication of his discovery of seeing bacteria and no one seemed to connect fermentation of cheese, wine, bread, etc. with these "little animals".

Definite and scientific evidence of the bacterial etiology of certain diseases was given to the world in 1876, exactly 200 years after microbes were discovered. Many reasons have been advanced to explain the time lag of 200 years. Poor optical equipment was one reason yet by 1830 excellent microscopes were being used. But more important was the persistance of erroneous ideas about the cause of disease. These ideas were mainly due to mans incapability of ascribing any obvious injury, illness or even

death to "little animals" that couldn't be seen by the naked eye. Hence, it was understandable that witch craft and the supernatural were large components of the early art of healing.

It is interesting to note that as the social order developed so did different theories of disease. The theurgical theory which was popular with Egyptians, Babylonians, Greeks, and Romans was later replaced by cosmatelluric causes such as eclipses, bad air, abnormal rains, doughts, etc. Later the thought that worms, insects, or even invisible animals might be the cause of disease was expounded by Frocastorious 1478-1553 who classified diseases into those transmitted by immediate contact or through intermediate agents like fomites and second group, diseases infecting at a distance or through the air as pestilential fevers. In 1658 Kirchner, a Jesuit priest who had a microscope claimed to have seen minute worms in the blood of plague patients which were probably rouleauex formation of blood cells. During the 18th century several men independantly developed "germ theories". Because bacteria could not be cultivated no one knew from whence they came and one man, Liebig, (1803-73) attributed the presence of bacteria in decaying matter to spontaneous generation from it.

Jacob Henle (1809-1885) published a book which tried to organize what had previously been known about bacteria and proceeded to outline a method for proving that certain specified bacteria would cause specific diseases. His student Robert Koch (1843-1910) carried

these postulates out by doing experimentation. A contemporary of Henle's Louis Pasteur (1822-1875), who was a chemist, added much to the history of microbiology. While working fermentation reactions he discovered that a type of organic acid would always be formed by the same type of bacteria. He also showed that heating wines and beer would kill off unwanted organisms and allow the correct types to ferment the wine. He also was able by luck and experience show experimentally that Lierig's theory of spontaneous generation was erroneous.

Surgery was to greatly benefit by the above work. Before that Henle had been ignored. Semmelweiss (1815-65), who didn't know of microbes, had been driven insane because no one would listen or utilize hand washing in maternity or surgical wards. At this same time Oliver Wendell Holmes had almost simultaneously concluded that pueperal fever was contagious.

Joseph Lister (1827-1912) was a surgeon and an investigator. He noticed early in his career the direct relation of broken skin over a fractured limb and the presence of inflammation and infection. He suspected something in the air and in 1865 read Pasteurs work and at once saw the implications. He hunted around for an "antiseptic" to kill the floating air-borne germs and began using carbolic acid.

However, due to the many unexplained varieties of disease no one paid much attention to Pasteur or to Lister.

Robert Koch worked with Anthrax and unequivocably showed that the Anthrax Bacillus caused the disease and he also did much to initiate Microbiology as a science and to promote techniques to grow and isolate organisms.

In 1875 Weigart showed that bacteria would stain with analine dyes hence once the isolation, cultures and staining of bacteria were available there followed in rapid succession one after another discovery of specific organisms. Antiseptic surgery later modified to aseptic surgery made possible the control of infection by denying access to the body of untold millions of bacteria.

MATERIAL AND METHODS

Scope of Study

The investigation was made in the services of general surgery, OB, Gyn, orthopedics, urology, thoracic and abdominal surgery. Because of the poor follow up, short hospital stays, and unfamiliarity with the study, ENT and oral surgery was omitted. Only those patients who had actual tissue incised or disrupted were used. Not included were simple fractures, epesiotomies, and biopsies of an internal nature i.e., bronchial, esophageal, and urinary bladder.

The study extended from November 28, 1959 through February 6, 1960, a period of ten weeks. One hundred and eighty-nine

operations were included. Approximately 30 cases outstanding when the study was terminated were not included due to the urgency of presenting this material. Five of these cases were from general surgery, twenty from gyn, and five from OB.

A. Incidence of Infection

1. By class of operation

An infection report form was attached to each patients chart in the operating room. (See Figur 1.) The report had space for name, age, hospital, service, surgeons, operation, classification of case and infection. There was also a space to be checked on the report after operation which classed the operation as clean, potentially infected and infected. Clean cases included those patients in which incision was made through an area not grossly contaminated. Potentially infected cases included (oral and anal surgery, cholecystectomy, appendectomy, intestinal resections); and infected cases included (trauma, burns, abscess drainage, secondary closure of infected tissue, excision of necrotic ulcers etc.).

2. By Class of Infection

There was a space to be checked by which the surgeon clinically gauged the presence or absence of wound infection. This was done by checking a column of none,

mild (redness or serious drainage about the sutures or pulling through of sutures), moderate (any pus, wound separation example - stitch abscess), severe (presence of frank pus, systemic manifestations of fever or septicemia. Examples would be peritonitis fistula formation and/or deep abscesses etc. The surgeon filled out the report at the end of the operation. He also recorded information on subsequent days during the patient's hospital stay.

B. Pathogenesis

1. Etiologic Organisms

No serious attempt was made in this study to ascertain the etiologic agent in wound infections. In those patients which did have cultures taken of an infected wound a note was made and tabulated in Table 8.

2. Factors Contributing to Infection

a. Personnel

There was no attempt made at noting the presence of resistant staphylococci carriers in the hospital personnel; however, the infection report form carried a space to note who the surgeons were in each procedure.

b. Environment

By utilization of a graph which registered post-operative day and first, second, third, etc. dress-

ing change it was hoped that the day of onset of infection could be pinpointed and if wound dressings had previously been done. This was done in an attempt to find where the infection started i. e. in the operating room or the ward.

c. Operative Techniques

On the infection report were listed 10 "remarks" which were utilized because of supposedly frequent association with poor wound healing. (Please see appended infection report Fig. 1). These remarks were to be checked by the surgeon as he finished the operative procedure.

d. Antibiotics

Two of the above "remarks" concerned pre-operative and post-operative antibiotics. These remarks were then carefully followed up to relate their pertinence to the patients hospital course.

C. Incidence of Septicemia as Important Factor in Death of Patients Coming to Autopsy

Autopsy records were studied in 1951 and 1959. These were studied from a bacterialogic standpoint. The cases coming to autopsy were listed by whether or not heart blood was drawn for culture and if good clinical evidence of infection was present at autopsy. It was hoped that a "pre-antibiotic-year"

study could be obtained but the number of cultures taken prior to 1951 were too few.

Table 9 shows the results of this study. These cases were classified by number of cultures taken and number positive. They were further subdivided into groups according to clinical presence of sepsis and positive post mortum cultures and evidence of sepsis but with negative cultures. Also the etiologic agent was listed.

Selection of Patients

A new report was made up for each patient if he had multiple procedures on seperate days. If the same patient had both a herniorrhaphy and a venous ligation and stripping at one operative period then both procedures were included on the same infection report. This was done so that each exposure to the operating theatre would be considered a new case.[26]

RESULTS

A. Incidence of Infection

1. By Class of Operation

189 patients were studied. These were shown in Table 1. Of the 189 cases 84 were classified as clean, 69 were classified as potentially infected, and 36 were classified as infected by the operative classification described above. Clean cases were 44 per cent of the total. Potentially

infected cases were 36 per cent of the total and 19 per cent were infected.

Of the 189 cases, one-fifth developed a reportable infection. The previous figure includes those cases which were classified by operational classification as infected and it also includes those cases which became mildly infected by the infection classification.

There were 84 clean cases 6 of which developed an infection of some type (Table # 2) an incidence of 7 per cent. Of these three developed a mild type infection 3.6 per cent. One developed a moderate type of infection 1 .2 per cent. Two cases developed a severe infection; an incidence of 2.4 per cent. The two cases which developed severe infection were from the OB service and were done three weeks apart by two different surgeons.

Of 69 potentially infected cases (Table # 3) one-fifth developed an infection of some type. Of the 14 infected seven were mild; four developed a moderate infection, and three cases which developed a severe infection.

There were 36 infected cases, 20 of which developed infection; 55.5 per cent. As noted in Table # 3, there was only one mild infection. There were fourteen moderate infections, in this group or 38.9 per cent and five severe infections or 13.9 per cent of the total of 36.

2. By Class of Infection

In reading the above material it soon becomes obvious that the cases reported as mild may be swaying the results. Mild cases were those that developed a redness about the suture or serious drainage. These cases could be due to hypersensitivity to the suture material or inordinate trauma in sewing. Another consideration is that operations classified under the operative classification as infected were cases of gross contamination and would be expected to remain infected. This is shown above to be true. IF the cases that were classified as clean or potentially infected are grouped together under a heading of "clean" and those cases in the infection classification which developed post-operative infections of a pertinent nature are grouped together as "serious" then a more suitiable comparison can be obtained.

In Table # 6 the 153 "clean" cases are compared to the number of "serious" infections that occurred. This table shows that an incidence of 6 per cent infection rate occurred. These are the cases where infection would not be expected to occur and when infection did occur it was of a serious nature.

In Table # 7 all cases which developed a severe infection are listed (10). It should be noted that one-half (5) were from originally infected cases. It is also pertinent that two cases were originally classified as clean and that these

two cases are from one service and had identical operative procedures.

B. Pathogenesis

1. Etiologic organisms

Table # 8 lists those cases which became infected and on which cultures were taken. There is no outstanding etiological agent. As would be expected, the enteric group were found in the grossly contaminated wounds or after bowel surgery. The hemalytic Streptococci were especially apparent in the two clean cases which subsequently developed severe infection.

2. Factors Contributing to Infection

a. Personnel

1). Hospital

It may be noted in Table # 8 that several of those cases that became severely infected did so after the fifth post-operative day. While results of the other types of infections are not shown, it was generally true that in all types of infection a good share occurred after the post-operative day five. Our hospital is not equipped to phage type Stapholococci or keep a close watch on nasal and skin carriers of resistant organisms. It is quite apparent that a good share of the post-operative wound infections were cross ward

contamination or contamination directly from personnel. This factor is discussed more fully later.

2). The patient

The bacteriology department of the University of Nebraska Hospital has mad e a survey of all hospital admissions showing that 15 per cent are infected in some way. This series showed that about one-fifth of patients coming to surgery were initially infected. Also the autopsy series shows that on-fifth of all patients coming to autopsy in 1959 had positive heart blood cultures. Correlation of these figures is made in the discussion. We have no figures on the per cent of patients being admitted to UNH with resistant organisms on their skin or in their nose.

b. Environment

There were no results noting the effect of air, housekeeping, etc. on the wound infection rate. This would be a relevent area of study.

c. Operative Technique

Several of the "remarks" listed in Figure 1 concerned factors in operative technique. It is noted in Tables 2, 3, and 4 that surprisingly many of these factors had no noticable effect on development of wound infection in this series.

d. Antibiotics

The last two "remarks" listed in Figure 1 dealt with pre and post-operative antibiotics. As noted in Tables 2, 3, and 4 there was a direct relationship between th use of antibiotics and development of wound infection. Of 10 cases considered "clean" developing "serious" infection 9 received pre or post-operative antibiotics.

C. Incidence of Septicemia as Important Factor in Death of Patients Coming to Autopsy

1. Non-operative Deaths

In 1951 seven patients with positive heart blood cultures at autopsy died with sepsis being a major cause of death, see Table 10. There were six additional cases with positive heart blood cultures at death in which it was undetermined if the agent grown on culture was of major importance as a cause of death.

In 1959 ten patients with positive cultures at autopsy died with sepsis being a major cause of death. There were eight additional cases in which it was undetermined as to the pertinence of the bacterial cultures.

These patients, 31 to 45 total positive cultures for the two years surveyed, had not been operated upon. The material in Table 11 does not show which of these patients underwent surgery but it does show the etiology found at autopsy. The organism found in these 31 cases were a wide variety of gram

positive and negative organisms with no one group outstanding.

2. Deaths after operation

In 1951 seven cases which had positive heart blood cultures at autopsy died post-operatively with bacterial infection and sepsis as a contributing factor. That is approximately one-third of those cases with positive cultures had been operated on. In 1959 there were seven cases which died post-operatively with positive heart blood cultures at autopsy. However, of these seven only three deaths could be directly attributed to the post-operative wound infection. The remaining four cases had a variety of complicating circumstances; for example, two cases had developed sepsis secondary to a massive broncho-pneumonia following operation. A third case developed leuko-penia secondary to a post-operative antibiotic and succumbed to generalized sepsis. The fourth case developed broncho-pneumonia after a leg amputation and a diptheroid species was isolated. The organisms found in the other 13 cases varied with the area operated upon i.e. coliforms were the usual organism cultured from those patients who underwent abdominal surgery. While those cases which unregardless of the type of surgery developed pneumonia often gave up gram positive organ-isms on cultures.

3. Septicemia - Total

a. Septicemia with bacteremia

Table 11 sums up the material gathered from a survey

of the 1951 and 1959 autopsies done at UNH. These cases were compared by the number of autopsies done and the number of blood cultures done. There were 130 autopsies performed in 1951 compared to an almost identical figure of 132 in 1959. in 1951, there were 45 blood cultures taken of which 20 were positive. There was a scattering of bacteria found, the majority being enteric organisms.

In 1959 there were 60 cultures taken of which only 26 were positive. Hence by increasing the number of cultures taken by 53 per cent, there was only 30 per cent increase in positive cultures. The majority of cases in 1959 which did not receive post mortum cultures were stillborn, abortions, and sudden accidential deaths. In 1951 the above statement was true also but there were considerably more patients who had evidence of clinical infection but did not have blood cultures.

b. Septicemia with no Cultures Taken

In 1951 there were 12 cases which had a highly suspicious history of severe infection before death but cultures were not obtained. By "highly suspicious" is meant fever, grossly infected organs or tissues, remarks by the pathologist pertaining to positive evidence of sepsis or areas on section which contained purulent material. There were only four such cases in 1959. Be-

cause cultures were not taken these cases can not be included in the above results but may have made a considerable change if they had been cultured at death.

c. Septicemia without Bacteremia

In 1951 there were four cases that had either clinical evidence before death of sepsis or the pathologist noted in the protocal that there was pathologic evidence of bacterial invasion but cultures were negative. This compares to nine such cases in 1959.

d. Bacteremia without Septicemia

In 1959 two patients had positive cultures of spinal fluid obtained at death yet blood cultures were negative. There was one case in 1959 reported as having heart blood containing E. coli but the patient had had hemalytic streptococci grown out in pre-mortum cultures. (Last column Table 10). Also several of the cases noted above had positive cultures yet post mortum established no real evidence of the organism's pathogenicity in cause of death. These cases probably belong in this group.

In 1951 there was less evidence gathered showing evidence of bacteremia without septicemia. This was probably due to fever cultures taken on patients without obvious sepsis.

DISCUSSION

Incidence of Infection

A. Present Study

This series reports an overall operative wound infection rate of 21 per cent (all cases). Since many of these were from infected cases and many others developed only mild infections a more pertinent incidence was 6.5 per cent. Table # 6. This was obtained from those cases initially "clean" and who developed "serious" infections. This study was moulded along the lines of a study by Jeffrey et.al.[27] and our results are shown in Table # 9 compared to that study and to various other studies. It may be noted that our series reports "trivial" type of infection to be equal with our "serious" cases. It is the authors opinion that there probably should have been more "trivial" cases but judging was left up to the surgeon and it was only natural that a mild case be over looked occasionally so that the stigma of "wound infection" would not be associated with that surgeon. It is of small note, however, as many of these "mild" infections may have been only hypersensitivity to the suture or to undue trauma at closing.

It is noteworthy that "serious" infections occurred with 3.6 per cent incidence in clean but not potentially infected cases while those of a potentially infected nature developed

a 10.1 per cent incidence, a significant increase. This rise in incidence can not be due wholly to long procedures of a traumatizing type because many Hysterectomies and Ceaserion Sections are included in the clean and not potentially infected group. However, it is true that many of these potentially infected operations were bowel resections etc.

It may be noted that of the 36 cases operationally classified as infected only 20 developed a wound infection. Often this wasn't a clear cut sudden onset of infection but was merely the prolongation of the original process, however, why didn't the other 16 cases develop infection? As discussed in under pathogenesis there are many varied factors concerning the initiation of wound infection. The mere presence of pathogenic bacteria is only one of these factors.

B. Other Studies

The incidence of surgical infections varies a great deal from hospital to hospital from one year to the next but is rarely if ever below one or two percent.[22,34,44]

Meleney (1948) reported a sepsis rate of 13 per cent in clean wounds in a 1925 survey. By 1933 this figure had fallen to 4.8 per cent and by 1942 to 2.6 per cent. Howe (1956)[22] reported fall from 3.98 per cent in 1950 to 2.14 per cent in 1955 and ascribed this improvement is improved aseptic technique and restriction of antibiotic therapy.

There is no evidence that todays Staphylococcus is more virulent than those of ten years ago. Rogers (1956)[40] showed that when identical types of infections are compared by age groups, there is no increase in the virulence of streptococcal infections. However, Harper (1954)[18] reported on a detailed study of hemalytic streptococcal infections in Glasgow, Scotland from the early 1930's till in the middle 50's and believes that the virulence of streptococcal organisms has decreased.

The presence of carriers of pathogenic staphylococcus organisms in the hospital personnel population has been the subject of detailed study[45]. Howe (1957)[25] recently published a review showing that after the start of a campaign to decrease wound infections in 1953 he succeeded in reducing the number of positive carriers in the personnel from 99 per cent in 1953 to 52 per cent in 1956. However, it should be noted that his overall clean wound infection rate decreased by half at first then rose to old levels and at one point even exceeded previous highs. Also, as the incidence of staphylococcal infections of the wound decreased, the number of infections due to enteric organisms increased. Nasal and skin carriers are here to stay. Because the hospital , by its inherent ability to isolate and cultivate resistant organism, can do little to decrease the number of carriers it seems reasonable that frequent culture and sensitivity and if possible phage

typing be done on personnel. There have been several articles reported in which a boil or furuncle was the basis of a severe outbreak of staphylococcal wound infection.[7,31] It seems evident that the area of cultivation of the pathogen is important. A pathogenic staphylococcus that has been harbored in a furuncle or carbuncle seems to be a very lethal agent when compared to the usual nasal or skin contaminant.

Pathogenesis

As shown below the etiology of most wound infections is a Staphylococcus in most hospital series. This is a very common organism; being found on skin, in noses, in air, in dust, and on fomites in home, work and hospitals.

This organism has become a severe problem in recent years in infections.

Knowledge of the pathogenesis of operative wound infections is important from the standpoint of prevention and treating the number of infections that occur.

A. Etiologic Organisms

1. Present Study

There were 14 cases of post operative wound infection on which cultures were taken. (Table # 8). Three of these cases cultured out hemalytic streptococci, two of which were from clean operative class infection. The remaining case was from an originally infected case and

also had gram negative rods isolated. These two clean cases developed severe infections and belie the common assumption that streptococcal infection are rather innocous. Of the 14 cases there were six cases which cultured out hemalytic Staphylococcus aureus at some time during their post operative course. This represents a majority of etiologic agents and substantiates the findings of most authors.

There was no great distinction between severe, mild, or moderate type of infection and the etiological agent cultured from the wound. However, it might be noted that the hemalytic streptococcal cultures were taken from severely infected cases while the staphylococcal and coliform organisms were cultured from smouldering types of wound infection.

This study was not based on an etiological basis and it should be noted that very little was discovered along this avenue, there being only 14 cases cultured out of 41 would infections. Twenty-nine of these would infections were of a "serious" nature (moderate and severe infection).

There was an inconsequential number of infected-type cases on which cultures were taken before surgery by which comparison could be made if infection developed in the wounds.

2. Other Studies

The etiology of the majority of post operative wound infection is due to Staphylococcus, usually var. aureous.[7,8,16]

Howe,[25,23] reports that on his services three-fouths of all staphylococci are resistant to one or more antibiotics. He also refers to the recent literature reporting the closing of surgical wards because of staphylococcal epidemics.

Tachdjian et.al.[44] did a careful survey of 3000 "clean" orthopedic surgical patients and found again that Staphylococcus led the list. He reported Micrococcus pyogenes aureus (coag. pos.) as the etiology in 54.51 per cent of 44 major infections. Var. albus was the etiological agent in 34.1 per cent of these major infections and the enteric organisms Proteus and Pseudemenas made up 93 per cent. Of the staphylococci isolated 89.7 per cent were resistant to penicillan. In another eight year series it was reported that the overall infection rate was from 1.19 per cent to 3.8 per cent and during the 1st four years staphylococci were the etiologic agents in 53 per cent of the major type wound infections and in the second four years period were the culprits in 78 per cent of the cases.[25] A little over 50 per cent of the general infected cases being of major type.

Staphylococci cause problems because they reside in almost every nook and cranny of home, hospital, or person. Their ability to rapidly become resistant to antibiotics is well recognized. Finland[15] reports that staphylococci can rapidly change their phage type and become suddenly resistant to some antibiotics. Combining this ability to their availability and then consider the type of smoulding hard-to-get-at-infection they produce makes one wounder why the problem isn't more severe than it is. McDonald et.al.[31] reports that a surgeon with a staphylococcal boil on his forearm operated on eight patients, six of whom developed serious wound infections. Staphylococcus of the 52A/79 type was cultured from these wounds. This report alone demonstrates the marked contagiousness of the organism. Byrne et.al.[8] demonstrated the availability of the organism by showing that most blankets on the surgical ward had positive cultures. All wards showed repeated positive cultures from air contamination and of the 10 operating rooms one half (5) were positive at 1 and 2 hours from air contamination. He also showed that 50 per cent of patients entering the hospital for surgery had positive skin or nose cultures and that 75 per cent of the staff and personnel were carriers of resistant Staphylococcus aureus.

Although staphylococci are a major headache they are not the only problem as has been shown by various authors. Lyons[28] showed that when stringent efforts were made to combat gram positive staphylococci the incidence of gram negative carriers in nose and skin began to increase. This was also reflected in a rising incidence of wound infections by gram negative organisms. He also states that the per cent of bacteremias caused by gram negative organisms and the resultant mortality from these infections has increased markedly in Boston City Hospital since 1931.

B. Other Factors

1. Personnel

a. The Hospital

The hospital staff and administrators play a part in the Pathogenesis of wound infections. The primary error made is mistaking a clean wound for a sterile one. And if a wound infection should occur it was because a pathogenic organism landed in the wound. All wounds are contaminated.[36]

b. The Patient

In discussing pathogenesis of post operative wound infections the most important point of all is the patient. The general health or debility, the presence or absence of dehydration, electrolyte balance, hemorrhage

and adequate nutrition will all play a part in whether or not wound infection is to occur. Dubos[13] has shown that he can change susceptibility in mice at will. At times in a matter of hours--to standard infection dose by causing 1). acute starvation 2). diabetes 3). various toxemieas and 4) subclinical allergic reactions. Mice aren't men but is is not too difficult to see a pattern of comparability to patients about to under go surgery. The setting in which the operation is done, the type of operation and whether or not private facilities and surgeons are used may all affect the production of wound infections according to Bohnson et.al.[6] This author believes that the lower economic standard, delay in getting the operation and higher probability of malnutrition all weigh against the indigent patient. Also he believes that extra stress and the type of surgeon who operates i.e. residents also tend to increase the incidence of post operative infections in the indigent. Age as a factor is indisputible. The added presence of complicating diseases in the elderly is often a factor. The susceptibility of the very young to overwhelming sepsis has been well documented. Malnutrition and generalized debility are a factor in these aged patients. Platt has shown that diet itself can be an important varient in producing wound

infections in experimental animals especially altering the protein and fatty constitients.[38] Popert et.al.[39] in a survey of patients who were on therapuetic doses of corticoids found that delay in wound healing did not occur. He also presents five cases in which patients were on large doses of corticoids and had active infections in the operative area yet wounds healed normally and rapidly. This last paper tends to Belie the strigent doctrine of corticoids markedly delaying wound healing especially in infected areas. The authors contention is that much of the previous work had been done in animals using massive overwhelming doses of corticoids. However, it is still a well substantiated fact that corticoids play a major role in collagen and protein formation but the adrenals and stress may be less important than is generally believed today.

The patient, as he comes into the hospital, can be a very important factor in the pathogenesis of post-operative wound infection.

2. Environment

a. Air

The operating Theatre can make or break a hospital's infection rate record. Burnett et.al.[7] showed that in his operating Suite the count of bacteria in the

air averaged from 38/5 cu. feet to 194/5 cu. feet. In various repeats of these studies only four colonies of hemalytic staphylococci were grown yet it was known that 8 of 18 theatre staff were nasal carrier of hemalytic staphylococci.

The ventilation of the O. R. has received considerable attention in recent years.[41] A method of forcing air into the O. R. suite from outside the building is especially recommended. While the author has no studies on air contamination in the Operating Suites at UNH, this should not be a major problem in the pathogenesis of infection as all suites have forced air conditioning with the intake located outside the building. The poorly controlled factor of air contamination is a fertile field for study. Duguid and Wallace[14] have shown that vigorous activity by one person can release up to 10,000 bacteria per minute carried in the dust from clothing. An ordinary surgical gown over these clothes can reduce the count by 50 per cent. Changing the pattern of air flow in the operating room can also be very important in reducing bacterial counts. The use of ultra violet light has been utilized for many years in reducing bacterial counts in operating rooms.

b. The Ward

The spread of wound infection about the wards

is often investigated. There are many ways in which contamination or cross contamination can occur. There has appeared in recent literature reports of closing whole surgical wards because of cross contamination.[5,7] Howe[21] reported that the incidence of cross infection has risen from one per cent to ten per cent from 1949 to 1954 mainly from Staphylococcus aureus.

Cross contamination can occur by many means--from dressing carts, surgeons fingers from the dust of the ward and from improperly laundered linen and blankets.[35,37]

The space on the Infection Reports for marking post operative day of dressing change was placed there so that we could try to pinpoint where infection was occurring. It was hoped that we could show that cases becoming infected before post operative day five were originally contaminated in O.R. or that it was due to a technical error. Those occurring after day five could be ascribed to ward contamination. Results were equivocal and could not be properly interpreted. This was due to an inherent error. If an infection occurred in a "clean" wound before post operative day five you could then say only that it was probably not due to ward contamination, however, you could not ascertain very certainly which of the Remarks checked was the pathogenesis or whether it was

due to an unknown technical factor or maybe it was due to the physiologic nature of the patient. It can be noted, however, that of the ten "serious" infections occurring in "clean" cases six occurred well after the fifth post operative day. The first dressing change had noted no clinical evidence of infection. Cross ward contamination is a real threat. Even though the University Hospital has an excellent set-up for dressing and isolating infected operative wounds; contamination apparently does occur. I believe one of the major problems is ward rounds! Consider for a moment that a patient has some how become infected and there is a yet fever or clinical evidence of wound infection. This patient is greeted by a troupe of surgeons who throw back his contaminated blanket showering the air and their clothing with bacteria of "proven" pathogenicity. Next it is often necessary to look at the wound, maybe only peek at it, but still, the dressing is disturbed and more bacterial float up. Then the group moves on to the next bed and if conditions are right this patient will be scarsely able to escape a wound infection. Maybe much of this is hypothetical but would infections are occurring on the ward. It may be that other factors yet not considered are of major importance.

c. Housekeeping

These services can be a great help in success-

fully cutting down ward infections.[1,5,9] As noted elsewhere blankets are almost always contaminated but effectively laundered linen seldom is. The type, frequency and time of the day floors are mopped or swept can be a factor. If the floors are swept an hour before dressing changes are done air contamination can be a real threat. The effectiveness of sterilization of equipment is unquestionably a factor in wound infection. The need of separate laundry of linen from isolation cases also goes without saying.

c. Wound environment-internal and external

The internal environment of the wound itself is often a basis for infection.[11] Poor hemostasis, avascularization and trauma to the subcutaneous fat is cited as an important factor in producing wound infections by McDowell.[32] This author also demonstrated a well known but little thought of physiologic consequence of surgery. He made a "sterile" incision in the back of ten rats. Then he placed a ligature around a 6-8 mm area of muscle of five rats, all rats were then inoculated in the operative site with approximately 1,000,000 hemalytic Staphylococcus aureus cultured from a human wound infection and all were then sutured up with fine silk. All five rats with comprimised muscle tissue developed severe

wound infection with abscess formation and drainage of pus but none of the other five rats had any complication whatsoever.

It seems apparent that from the literature the most effective type of dressing has not been found. Some use little or no dressings and keep air and dryness at a maximum.[20] Their results compare very favorably with other surgeons who use thick occlusive type dressings. There also have been several experiments using a plastic spray which may or may not be effective.[29] The plastics here-to-for have caused considerable maceration of the skin it covers. UNH uses an occlusive type dressing with good results on major incisions and a "spray" type on minor small incisions. As yet there seems to be no evidence that either is superior if used on all cases.

An occlusive dressing has many drawbacks. The main fault is that it is a perfect siphon if it becomes soaked clear through.[10] Bacteria landing on the dressing easily gain access to the wound. When to change a dressing is important. If changed too often there is greater risk of contamination through technique or from the air. If changed too infrequent the dressing itself becomes a veritable culture media for bacteria. The dressing is an important aspect of the wounds external environment.

However, the type dressing is likely of far less importance in the overall result than is carefull application frequent changes and asceptic technique in the attempt to reduce post-operative wound infections.

Operative techniques as used here includes many of the aspects that are usually thought of as being of rather minor importance. That is routine procedures that are done daily as a ritual but with very little conscious thought given to their importance.

e. Handscrub

The popular 2-5 minute hand scrub with hexachlorophene has been shown to be less than effective.[4] However, it is probably adequate if a glove is not punctured during surgery. The reader is referred to Table # 3 where column six under Remarks notes the number of glove perforations occurring during an operation. It is noted that in all cases becoming infected only one case had this remark checked. Why? Glove perforation occurred during an operation 19 different times. It may be that the strict supervision of 10 minute scrubs or 5 minute scrubs if 24 hours or less had elapsed has effectively lowered bacterial counts so as to negate the dangers of perforation.

f. Masking

Effective masking especially using the double mask technique and changing the outer one hourly is highly

recommended in decreasing the incidence of wound infections.[2,23] An attempt to study the effacy of a single mask, a double mask and an experimental disposable mask was carried out at UNH in 1959. By holding the culture plate at a 24 inch distance from the face and comparing quiet breathing, talking, whispering, etc. and changing masks after each test, it was found that there was no appreciable differences in any one type. However, the longest any one type of mask was worn was about five minutes; hence, the factor of moisture condensation did not enter the experiment. A wet mask transmits bacteria much more readily than a dry one, therefore, it would appear that a thick double mask and hourly changes are both desirable techniques.

g. Drapes

It has been shown that one dry treated drape is impervious to bacteria while as many as ten soaked drapes readily transmit bacteria.[43] The UNH hospital uses the multiple drape technique.

h. Skin preparation

Skin preparation has received considerable attention in recent years.[4] One report states that they reduced the incidence of staphylococcal wound infection from 15 per cent to 3.7 per cent mainly by changing from

acriflavine as a skin antiseptic to tincture of iodine.[19] The above report might be cited as a instance where the sudden focus of attention on wound infections might have had considerable sway on the results. Bryne et.al.[8] reports a study in which 34.6 per cent of patients studied had positive cultures from the nose, 11.5 per cent of the skin and 3.8 per cent had both positive for pathogenic staphylococci. Further study showed 10 per cent of 57 patients had positive cultures in the area of the skin incision. On these 57 patients two G-11 scrubs were done followed by ether then 70% alchohol and tincture of zephiran. 80.7 per cent of these prepared areas were then negative on culture and there were no increase in the number of positive cultures at the time of skin closure. However, Hampton[17] in another paper reported that the number of positive cultures ar closure time was higher than the number of positive cultures of unprepared skin.

The wet shave with a sterile razor, green soap, and water followed by a hexachlorophene was recommended by McDowell.[32] A quick dry shave followed by little or no effective washing can render a modern antiseptic or detergent less than effective.

3. Operative Techniques

Techniques that the surgeon has closer control over

and which often does the most to perfect are those associated with the operative procedure itself. As noted on the infection report (Figure 1) four of the "remarks" to be checked were concerned with factors in operative technique.

a. Incomplete Hemostasis (remark #1)

This remark was checked 23 times in the total series of which infection occurred in 10. Of these ten only one occurred in a "clean" case the other nine occurring in originally infected cases. Hence, it would appear that incomplete hemostasis had little or no effect on the incidence of infection in "clean" cases. Yet, it cases operated upon which were infected (total of 36) there were 19 "serious" infections and this remark was checked in 9. A very significant finding. This could be interpreted as showing that the increased amount of blood oozing into the wound developed perfect culture media for the bacteria present. Or it could mean only that residents were significantly more observant in recording these type cases. This is based on the finding that "remarks" were not checked at all in 58 cases only five of which developed "serious" infection. Results of any investigation can be only as valid as the reliability of the constituents.

b. Anastomatic Insecurity (#2)

This was checked in a total of five cases none of which developed any type of infection.

c. Dead Space (#3)

This was checked in 38 of the total cases. Only one case had this checked which was "clean" and developed a "serious" infection, however, 10 of the 38 were checked in those cases classified operationally as infected. I believe the major importance of this "remark" is its validity as a "remark" in that it does occur quite regularly in surgery on these services.

d. Drain Left In Place (#4)

This remark was checked 33 times. It was checked only one time in the "clean" cases developing "serious" infection. It was checked 26 times in all types of cases which developed no infection at all. Hence this procedure may be more innocous then we've been led to believe.

Another factor is the suture used. Bohnson et. al.[6] reported several cases of resistant staphylococcal infections developing in the operative site in which silk sutures had been placed in or near the heart in cardiovascular surgery. All casesdid not respond to massive doses of antibiotics and 3 cases did not produce positive cultures until it was grown from the offending sutures after subsequent operation. This author also demonstrated

that sutures, minimally contaminated with Staphylococcus aureus (coagulase positive), implanted in dog hearts which were silk, steel, nylon, dacron, and catgut led to formation of infected granulomas from which organiam could be cultured for as long as six weeks. It is also of interest that infection resulting from catgut sutures have been observed regularly to subside spontaneously after three weeks presumably due to absorption. The point being made here is that any foreign body whether it be dead blood, fat, steel, nylon, etc. it is a potential source of irritation to viable tissue and can consequetly become the culture media for implanted organisms.

It was noted in the study that the remark "non absorbable suture used in places other than skin" was checked 65 times. It was checked three times in "clean" cases developing "serious" infection. It was checked three times in all the operatively classified <u>infected</u> cases. Hence in the majority of instances infection did not occur as a result of this factor.

4. Antibiotics

a. The study

"Remarks" 9 and 10 of figure 1 were concerned with the use of pre and post operative antibiotics.

Preoperative antibiotics were given 37 times. Of the 37, 13 cases were those operationally classified as infected. Of these 13, 10 developed "serious" infection and two developed no infection. On the surface it appears that in these cases prophylactic antibiotics did more harm than good. The total number of these infected type cases totaled 36. Nineteen of which developed "serious" infection, one developed a mild infection. One half of the patients developing "serious" infection received pre-operative antibiotics, (10 of 19). Not too much can be assumed from this, however, as several received antibiotics only for "gut sterilization" and also one can't be certain that the mortality rate wouldn't have increased if antibiotics had been with held.

Four of the 37 cases given antibiotics and classed as potentially infected developed "serious" wound infections. In this group of 69 potentially infected cases 12 received pre-operative antibiotics. Hence one-third of those given antibiotics developed "serious" infection. Of the clean but not potentially infected cases only three received antibiotics and non developed infection.

The use of post-operative antibiotics may be related to treatment but many of the cases were given antibiotics to prevent infection. Fifty-seven cases were given post-

operative antibiotics. Twenty-five of which were originally infected. Of this latter group, one-half (13) developed "serious" infections and 11 developed no infection. Of the "clean" type cases (clean plus potential) 32 received such antibiotics. Six of these 32 developed "serious" infection which shows a considerable increase over the average incidence of infection in these "clean" cases (18.7 per cent compared to 6.5 per cent, see Table # 5). Therefore, it seems apparent that pre and post operative antibiotics had a share in promoting post operative wound infections in this study.

b. Other studies

There has been much written in the last few years concerning the prevention of surgical infection by the use of prophylactic antibiotics. Howe[25] states that the incidence of antibiotic resistant organisms in a carrier population such as hospitals is in direct proportion to the frequency with which the antibiotic is used. Barnes et.al.[3] in a study of 1007 cases concluded that prophylactic antibiotics did not decrease the incidence of wound infections but actually increased it. This survey shows that the prophylactic use of antibiotics may have so decreased populations of non pathogens that it allowed a free field in the wound's environment

for the resistant organism growth. Strode[43] maintains that the virulence of these resistant organisms hasn't increased but that technique in aseptic measures has decreased.

Tachdjian and Compere[44] in a study of 3000 clean operations, 1900 of which received prophylactic antibiotics and 1100 which did not, showed that there were 1.89 per cent major infections in the prophylactically treated and 0.73 per cent major infections in those who received no antibiotic initially. He noted that of those given penicillan alone 13.2 per cent became infected; those given Penicillan and Streptomycin had an incidence of 8 per cent while those given Ilotycin and Sulfa had an incidence of 9.6 per cent. In 1945, Meleney[33] reviewed 2000 cases of soft tissue wounds, compound fractures and burns and found that Sulfa either locally or systemically or both did not reduce either the incidence or severity of local reactions.

There has developed similar evidence regarding newer antibiotics.[12] Cutler reveiwed 250 soft tissue wounds and compound fractures and found that Penicillan did not decrease the amount or quantity of infection. Sandford et.al.[42] found that systemic therapy with newer antibiotics did not decrease the incidence of wound infections in

experimental animals. Both Howe[24] and Adams[2] reported terminating the use of prophylactic antibiotics on their services.

Therefore, the pathogenesis of wound infection in surgical cases is due to a variety of factors. Some are inherent to the field of surgery i.e. the patient's physiology. Other factors are more technical in nature and are preventable to a degree. The latter factors are those of operating room techniques and operative techniques etc. These factors will vary in importance from one hospital to another but as yet there is no substitute for careful, intelligent routine asceptic techniques and careful physiologic surgical techniques.

Incidence of Septicemia at UNH

This study substantiates much of what has previously been noted concerning the seriousness of staphylococcal infections.

In all of these autopsies only one was posted as long as 5 hours after death and in this case blood was not taken for culture. In majority of cases post mortum blood was drawn before 3 hours had elapsed.

There were 130 autopsies performed at UNH in 1951, 45 of which had heart blood drawn for culture. This compares to 132 autopsies in 1959 of which 69 had heart blood cultures. This majority of cases not receiving blood sampling were still-births, premature

infants and emergency cases which succumbed quickly and in whom bacterial etiology of their demise was not suspected.

A. Positive Cultures

Fourty-four per cent of the cultures taken in 1951 were positive an overall incidence of 15.4 per cent (see Table # 10). This compare d to 38 per cent positive in 1959 with an overall incidence of 20 per cent.

At first glance it would seem that antibiotics were not in common use in this hospital. Many of these cases had terminal pneumonia, many had carcinoma with terminal carcinomatosis and not a few died of leukemia. Thus, it is obvious that antibiotics probably did prolong life in many cases but the physical condition of the patient was such that death was inevitable.

The 53 per cent increase in blood samples taken in the 1959 series did little to increase the number of positive cultures. As will be shown later, this may be due to large scale use of antibiotics.

B. Staphylococcus and Streptococcus Bacteremia

There were seven heart blood cultures positive for staphylococci or streptococci in 1951 compared with 25 in 1959. This represents a marked increase in gram positive cocci septicemia. It is interesting to speculate about the cause of this increase. There is a greatly expanding resevoir of resistant staphylococci

in the hospital and general population alike. There is no such evidence concerning pathogenic streptococci. However, as shown in table # 10, staphylococci and streptococci increased almost equally over the 9 years. It may be that the use of blood spectrum antibiotics has greatly curtailed growth and invasion of the enteric organisms even after death but has had a less significant effect on gram positive organisms.

C. Clinical Evidence of Infection

In 1951 there were 12 cases in which cultures were not done yet there was clinical evidence of pre-mortum sepsis or wound infection. In several of these cases the pathologist noted that there was gross or microscopic evidence of sepsis. This type of case dropped to only 3 in 1959. This is most likely the effect of doing more blood cultures in 1959.

The cases which were reported to have negative cultures yet had clinical evidence of infection at post mortum averaged about 10 per cent of each of the two years even though 24 more cultures were obtained in 1959. This may be further evidence relative to the potency of modern antibiotics or it may be interpreted "side ways" to show that bacterialogists do show pertinent results on these cultures. That is, one wouldn't expect so many of these cultures to be negative if the lab was in the habit of turning up contaminents.

The autopsy report convincingly shows the pertinent in-

crease in gram positive cocci infections at autopsy. Whether the increase is due to antibiotic resistance in the case of staphylococcal septicemia, increased pathogenicity of staphylococci or better "isolation" by blood spectrum antibiotics has not been established.

It is of interest that the incidence of clinical infection of some type in a UNH admission is 15 per cent. The average incidence of bacteremia at post mortem is 17.5 per cent.

D. Bacteremia and Cause of Death

In 1951 six cases with positive heart blood cultures had severe peritonitis before death, five had severe abscess formation, two had acute sepsis and one had a severe superficial wound infection. Of the six remaining cases the positive culture found at autopsy may or may not have been a pertinent etiologic agent in the patients demise. One of the latter six died of a craniophryngioma, spiking fever and bilateral bronchopneumonia. Hence, this may have certainly attributed to death. In the other five cases three cultured out an E. coli which seemed poorly correlated with the patients cause of death (bronchial ca., bronchopneumonia and uremia, acute leukemia and bronchopneumonia). The fourth case cultured out a pigmented non spore forming gram positive areobic bacilli (bronchopneumonia and pancreatitis and pyelonephritis). The fifth case was 13 months old and succumbed to metastases of

of neuroblastoma, heart blood revealed a non hemalytic streptococci.

In 1959 two cases had severe sepsis, six had severe abscesses, one had peritonitis, wound abscess and lung abscess and two died of severe fulminating aspirational pneumonia. There were 15 cases which had "other" causes of immediate death. The author looked through these cases leaving out those which had what was apparently a severe infection with hemalytic Staphylococcus aureus or beta hemalytic Streptococcus. Of the remaining eight: one case had a non hemalytic streptococci and a non hemalytic Streptococcus and E. coli (bronchogenic Ca., with cerebral metastases and bilateral bronchopneumonia), four cases had enteric organisma ps aur., A. cloacoe, E coli, fecal streptococci. They succumbed to (A. acute leukemia and severe pulmonary edema, B. Myelogenous leukemia, severe bilateral bronchopneumonia and pulmonary infarction; C. Acute leukemia, bilateral bronchopneumonia, multiple furuncles and Pathology believes a staphylococcal sepsis also; D. Staphylococcal pneumonia, fibrinous pericarditis and hydrothorax) respectively. One case had a bilateral pneumonia and pulmonary edema was age 37 and had a non hemalytic staphylococci on heart blood culture that Bacteriology thought was a contaminent.

The seventh case died of massive pulmonary emboli and infarctions, pneumonia and pyelonephritis culture revealed a

diptheroid species. The eighth case died of inanition from carcinomatosis of melenoma heart blood cultured out a flavobacterium.

From the above materialone might state that it is not true that UNH patients are dying from their terminal disease and that sepsis is only a secondary finding. On the other hand it cannot be strictly stated that infection is killing the majority of these hospitalized patients. I do believe these findings show that in 1951 more patients died with a concomitant severe infection than those cases in the 1959 series.

Again I believe that here is solid evidence showing that broad spectrum antibiotics may be slowing the mortality rate of gram negative infections but in cases associated with debilitating disease gram positive organisms aren't being equally affected.

Prevention of Wound Infection

A. Wound Management

Wound Management has already been stressed as being paramount in wound infection, careful hemastasis clean incision, gentle retraction, sutures of absorbable material, elimination of dead space and care in keeping the operative site dry and uncontaminated are all important. Also the preparation of the skin needs reemphasizing. Note of the almost usual healing by primary intent of the emergency room

laceration in unprepared skin is suggested to the reader. The occasiontal primary healing without evidence of infection resulting in cases of gross fecal contamination is to be also noted. Another frequent finding is that of primary healing of initially infected tissues which were opened for one reason or another.

Long before antibiotics local and complete excision of devitalized tissues was the main treatment plus removal of pus and exudates by drainage, irrigation and absorption.

Such treatment consists of frequent inspection, cleansing, dressing changes etc. and usually results in a clean wound in a matter of days.

Conversely the practices which block such treatment are those of infrequent occlusive dressings, reliance or enigmatic debridement and antibiotics.

Occlusive dressings are very acceptable if frequently changed. A thick porous dressing that adsorbs exudate, allows areation and which is changed before becoming soaked will promote far better healing than the usual occlusive dressing. These rapidly become soaked and cause maceration of the wound and bathe it in pus.

The usual method of isolating an infected wound case further hampers effective treatment as it also effectively eliminates techniques of prime importance to good surgical

care i.e. availability of adequate dressings, instruments, lights, dressing tables, and personnel from patients who need them the most. Under these circumstances wound treatment often degenerates into infrequent dressing changes, cultures on dead tissue and worthless administration of antibiotics.

Whatever treatment the all material removed from the area of disposible value should be wrapped in impervious containers and incinerated.

B. The Ward

Wound infection on the ward is a problem.[30] Howe[21] reported an incidence of cross infection on his service which has risen from one per cent in 1949 to 10 per cent in 1954 mainly from Staphylococcus aureus. Ward infections can be very dangerous and almost every series reports one or more cases in which spread occurred in this way. Strict isolation technique as soon as an infection is discovered with careful aseptic disposal of all disposable material from that room should be utilized. Byrne et.al.[8] demonstrated using open agar plates on the wards that the air is contaminated at all times. This author advocates that all dressings be changed before mopping or dusting is done. On the ward, linens are often found to be negative for pathogens but blankets are frequently positive.[32] Also dressing carts are all positive unless thay have been recently wiped with 70 per cent

alcohol. Many other suggestions by this author are in general practice in most hospitals and don't bear repeating.

C. Antibiotics

The limited use of antibiotics in post operative wound infection has already been exhaustively discussed. The limited uuse of antibiotics in treatment has also been established.[17] Hampton has written a paper on the basic procedures for treatment of local infections. He maintains the basic difficulty is that most wound infections are due to staphylococci which produce proteolytic enzymes which in turn cause tissue necrosis. Antibiotics however, can only inhabit the organism but cannot neutralize the enzymes. Thus, any value of antibiotics is to delay and slow the invasive process. Most infecting organisms aren't capable of this type of invasion anyway excepting hemalytic streptococci.

Therefore, the best treatment is prevention. Prevention as outlined previously is really genuine interpretation and practice of factors which initiate pathogenicity.

SUMMARY

Incidence of Infection

For a ten week period from November 28, 1959 through February 6, 1960 all operational wounds of the General Surgery and OB-Gyn services were carefully followed up.

These wounds were operationally classified as either clean, potentially infected, or infected. And if infection occurred it was classed as mild, moderate or severe.

Of the 189 cases followed 36 were initially infected and 20 remained so. Eighty-four of the cases were considered clean and 69 were considered potentially infected. These 153 "clean" cases developed "serious" infection at a rate of 6.5 per cent. There was an additional 6.5 per cent incidence of trivial infections.

Pathogenesis

An infection report was utilized listing ten "remarks" noting the presence or absence of pathogenetic possibilities. It was shown that pre and post-operative antibiotics seemed to have the most direct correlation with development of infection in the ward.

The Infection Report also carried a space to correlate the post operative day of dressing changes with the first day of infection if any was noted. This tended to show that most"serious" infections were occurring on the ward. The likely areas of possible cross ward contamination were fully discussed, however, no conclusions could be made concerning this study.

Incidence of Septecemia

There was no outstanding etiologic agent noted during the study. The autopsy reports of 1951 and 1959 were studied from the viewpoint of sepsis at the time of autopsy. There was nearly an identical number of cases posted in each year. Comparison of the two years shows a definite upswing in the number of cultures positive for gram positive cocci. A comparison of the significance of a positive blood culture in the patients demise tends to show that there is a definite relation between the presence of a gram positive coccic bacteremia and the major cause of death.

Prevention of Wound Infection

Prevention of wound infection vitally concerns hospital personnel, from the chief of the surgery service to the janitor who mops the wards. Prevention means that those interested understand the pathogenetic factors and know how to cure them. It entails careful restriction of pre and post-operative antibiotics, asceptic operating Suite techniques, and asceptic wound dressing care in an atmosphere that is as "clean" as possible.

It has been said that anyone who looks for post-operative wound infection will find it. However, it does not necessarily folow that anyone who sets up a strict asceptic routine in OR and ward will succeed in curbing infection. A "Routine" must be just that a prescribed course to follow daily that is simple, obvious and not a great deal different that what the OR personnel and nurses

have been taught in training. Otherwise the routine will fail through human error.

Treatment again is Prevention of infection. If infection does occur adequate drainage, specific antibiotics, debribement and secondary closure were the factors most often suggested in the literature to be helpful. Adequate facilities and trained nursing care of infected cases in isolation is of prime importance if prevention of cross ward contamination is to occur.

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Robert Miller

TABLE I

OPERATIVE CLASSIFICATION OF 189 PATIENTS AND INCIDENCE OF WOUND INFECTION

	ALL PATIENTS		WOUND INFECTIONS	
	Number	Per Cent	Number	Per Cent
Clean	84	44	6	15
Potential	69	37	14	35
Infected	36	19	20	50

TABLE II

Patients Classified as

CLEAN CASES - 84

Infection Classification	Remarks											
	#	1	2	3	4	5	6	7	8	9	10	None
None	78	8	3	11	11	0	10	8	28	3	9	28
Mild	3			2	2			3	1		1	
Moderate	1											1
Severe	2										2	
Total of those with Infection	6			2	2			3	1		3	1
Total of those with no Infections	78	8	3	11	11	0	10	8	28	3	9	28

TABLE III

Patients Classified as

POTENTIALLY INFECTED - 69

Infection Classification	#	Remarks 1	2	3	4	5	6	7	8	9	10	None
None	55	3	2	10	19	2	7	16	28	9	16	14
Mild	7			1	2	1	1	2	2			1
Moderate	4	1			1			1	1	2	2	1
Severe	3			1	2		1		2	1	2	
Total of those with Infection	14	1	0	2	5	1	2	3	5	3	4	2
Total of those with no Infections	55	3	2	10	19	2	7	16	28	9	16	14

TABLE IV

Patients Classified as

INFECTED CASES - 36

Infected Classification	#	Remarks 1	2	3	4	5	6	7	8	9	10	None
None	16	2	0	3	3	1	0	2	1	2	11	10
Mild	1	0	0	0	0	0	0	0	0	1	1	0
Moderate	14	9	0	9	2	1	0	0	1	7	9	2
Severe	5	0	0	1	2	0	0	1	1	3	4	1
Total of those with Infection	20	9	0	10	4	1	0	1	2	11	13	3
Total of those with no Infections	16	2	0	3	3	1	0	2	1	2	11	10

TABLE V

PERCENTAGE INCIDENCE OF INFECTION

IN "CLEAN" WOUNDS

	No. of Wounds	Mild	Moderate	Severe	Total
Wounds Classified as Clean and not Potentially Infected	84	3.971	1.190 3.571	2.381	7.142
Wounds Classified as Clean but Potentially Infected	69	10.145	10.145 5.797	4.348	20.290
All Wounds Classified as "Clean" at Operation	153	6.536	6.536 3.268	3.268	13.072

TABLE VI

PERCENTAGE INCIDENCE OF "SERIOUS"

INFECTION IN "CLEAN" WOUNDS

"Clean"		"Serious"		% Incidence
Clean	84	Moderate	5	
Potential	69	Severe	5	
	(153)		(10)	6.536

TABLE VII

COMPARISON OF THOSE CASES BECOMING SEVERELY INFECTED

Operation Class	Operation	Service	Remarks	Post-OP Day	Culture
Clean	Low transverse Ceaserian Sect.	OB	10, endo. met.	?	Hem. Strept.
Clean	Low transverse Ceaserian Sect.	OB	10,	?	Hem. Strept.
Potential	Subtotal Gast. ric Resection with Vagotomy	Surg.	4,8,10	5th	Hem. Strept. aureus
Potential	Subtotal Gast- ric Resection with Vagotomy	Surg.	6,	7th	No growth 48 hours
Potential	Abdominal Re- section of Re- ctosigmoid	Surg.	3,4,8,9,10 wound inf. with separation	8th	C. coli
Infected	Skin Graft to Infected Burn	Surg.	9,10	4th	Non Hem. Strept. aureus, later Hem. Strept aureus
Infected	Rt. Middle Lobectomy	Surg.	3,4,7,8,9,10 Asp. & Exp. 3rd POD	At. Surg.	GM - Rds Hem Strept.
Infected	Drainage of Parotid Abscess	Surg.	4,9,10	3th 5th	Hem. Staph. aureus
Infected	2°Closure of Dehiscence	Surg.	Not noted	At Surg.	Hem. Staph. aureus & later E. coli & Non Hem. St.
Infected	Trauma?	Surg.	10,	7th	Not done.

TABLE VIII

ETICLOGY OF ALL CASES THAT WERE CULTURED

Cases with Infection - 41

Cases Cultured - 14

Operative Class	Infection Class	Procedure	Post-OP Day	"Remarks"	Culture
Clean	Severe	C - Section	?	10, Endometritis & wound Infection	Hem. Strept.
Clean	Severe	C-Section	?	10, wound infection	Hem. Strept.
Potential	Moderate	Gunshot Wound	7th	3,4,7,8,10	Ps. aurg & non Hem. Staph.
Potential	Severe	Subtotal Gastric Resection Vagotomy	5th	4,8,10, later ward dehiscence (infected)	Hem St. aureus
Potential	Severe	Subtotal gastric Resection Vagotomy	7th	6, dehiscion of part of wound & drainage of large amounts of pus	No growth - 48 hours
Potential	Severe	Abdominal Resection of Recto Sigmoid	8th	3,4,8,9,10 wound infection with separation	E. coli
Potential	Moderate	Supra pubic Cystostomy with Resection of bladder neck	4th by 8th	9, wound infection cleared with dressing changes and hot packs	Ps. aurg.
Potential	Moderate	Enterolysis Appendectomy	9th	9,10	E. coli
Potential	Moderate	Rt. ear Polypectomy with chronic otitis	Before OP & After	10, Chronic otitis media present at surgery	Ps. aurg. & Hem. Staph.
Potential	Moderate	Rt. aural Polypectomy, as above	"	1, chronic otitis persisted	Ps. aurg. & Hem. Staph.

TABLE VIII CONTINUED

Operative Class	Infection Class	Procedure	Post-OP Day	"Remarks"	Culture
Infected	Severe	Skin Grafts to burn area	POT	9,10 - POT injected in burn area, graft took	non Hem. Staph later non Hem. Strept. aureus
Infected	Severe	Rt. Middle Lobectomy	On OP Day	3,4,7,8,9,10 POT Asp. infected at separation-Exp. 3rd	GM - Rods Hem. Strept.
Infected	Severe	Drainage of Parotid Abscess	Surg. 3rd Redness draining 5th	4,9,10 - slowly healed	Hem. St. aureus
Infected	Severe	2° closure of dihiscence	At Surg.	None noted	Hem. St. aur. later non Hem. Staph & E. coli

TABLE IX[1]

INFECTION RATES IN DIFFERENT HOSPITAL[2]

Reference	Hospitals	Year	No. of Wounds	Serious %	Trivial %	Total %
Meleny (1935)	Presbyterian Hospital, New York	1925	958	4.0	10.0	14.0
		1926	1132	4.0	11.0	15.0
		1933	1053	1.1	3.6	4.7
Howe (1954)	Massechusette Memorial Hospital, Boston	1953	429	4.6	2.5	7.1
Clarke (1957)	Bristol Royal Infirmary	1953	382	6.5	7.1	13.6
Jeffrey (1958)	Edinburgh Royal Infirmary	1956	673	9.8	16.3	26.1
Present Series (1960)	Univeristy of Nebraksa Hospital	1959 1960	153	6.5	6.5	13.0

1. This listing is of "clean" wounds in all instances.

2. See Bibliography # 26.

TABLE X

RESULTS OF AUTOPSY STUDY IN THE YEARS 1951 AND 1959

	1951[2]	1959[3]
No. of Autopsies	130	132
Blood Cultures	45	69
No. Positives	20	26
Etiology		
1. Sretptococci		
Hemalytic	1	8
Non Hemalytic	2	5
2. Staphylococci		
Hemalytic	3	9
Non Hemalytic	1	3
3. Coli forms		
E. coli	8	4
	2	1
Pseudomonas	2	2
B. Subtilus	1	0
4. Miscellaneous		
Non spore forming	3	0
Achromalacti	2	2
Micrococcus	2	0
Pseudodysthroid	1	1
5. Other	3	3
Not done but positive history[1]	12	3
Reported negative but positive history	4	9
Reported positive but negative history	0	1[4]

1. This column includes those cases which were chosen on the basis of clinical history, diagnosis, pathologist's findings and opinion and the presence of laboratory or clinical data suggesting sepsis.

2. There were four cases in 1951 which cultured out multiple organisms from the heart blood.

3. There were nine cases in 1959 which had multiple organisms grown from heart blood culture.

4. This case had severe bronchopneumonia, multiple furuncles, the pathologist also gave an opinion that there was staphylococcal septicemia present. Heart blood cultured only E. coli.

INFECTION REPORT

NAME: _____ HOSP. NO.: _____ DATE: _____

SERVICE: _____ SEX: _____ AGE: _____

SURGEONS: _____

OPERATION: _____

OPERATIVE CLASSIFICATION: (Please Check)

SEE REVERSE SIDE BEFORE COMPLETING:

- ☐ 1. CLEAN
- ☐ 2. POTENTIALLY INFECTED
- ☐ 3. INFECTED

INFECTION CLASSIFICATION

1. NONE
2. MILD
3. MODERATE
4. SEVERE

REMARKS

- ☐ 1. Incomplete hemostasis.
- ☐ 2. Anastomotic insecurity and/or increased tension.
- ☐ 3. Dead space.
- ☐ 4. Unpredictable contamination of wound.
- ☐ 5. Break in aseptic technique.
- ☐ 6. Rubber glove perforation.
- ☐ 7. Drains left in place.
- ☐ 8. Nonabsorbable suture used, excluding skin.
- ☐ 9. Preoperative antibiotics.
- ☐ 10. Postoperative antibiotics.
- ☐ 11. _____

_____

DRESSING CHANGE

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1																				
2																				
3																				
4																				
5																				
6																				
7																				
8																				
9																				
10																				
11																				
12																				
13																				
14																				

Post Op Day

REMARKS: _____

_____

CULTURE: _____ SIGNATURE: _____

OPERATIVE CLASSIFICATION

Note: This is a general guide only, The final decision will be left to the surgeon.

GENITO-URINARY	Class 2,except vasectomy and orchiectomy which are Class 1.
GASTROINTESTINAL	Class 2 if bowel is opened.
MOUTH	Class 2.
ANUS AND RECTUM	Class 2.
BOWEL OBSTRUCTION	Class 2. If bowel viability impaired, Class 3.
ORTHOPEDICS	Class 1, except compound fractures which are Class 2, and osteomyelitis as Class 3.
THORACIC	Open heart operations Class 1. Lung operations Class 2.
TRAUMATIC INJURIES AND LACERATIONS	Class 2. If over 8 hrs., Class 3.
HERNIORRHAPHIES	All Class 1.
OBSTETRICS AND GYNECOLOGY	All vaginal work Class 1; 3rd degree laceration repair, Class 2. Uterine and adnexal operations, Class 1 except P.I.D. as Class 2 or 3. C-Section Class 1, except after ruptured membrane over 12 hrs., Class 2. Vulvectomy Class 1; Bartholin cyst Class 2 or 3.

WOUND CLASSIFICATION

1. Clean

2. Mild - any redness of wound or stitches, without exudate.

3. Moderate - any inflammation or infection of wound with the presence of small amounts of exudate. Example - stitch abscess.

4. Severe - frank pus, either superficial or deep; evidence of generalized sepsis, thought to be secondary to operative procedure and present deep in the body.
   Examples - Peritonitis, osteomyelitis, bacteremia, septicemia, internal abscesses, bronchopleural fistulae.

mrc/jc
11-24-59

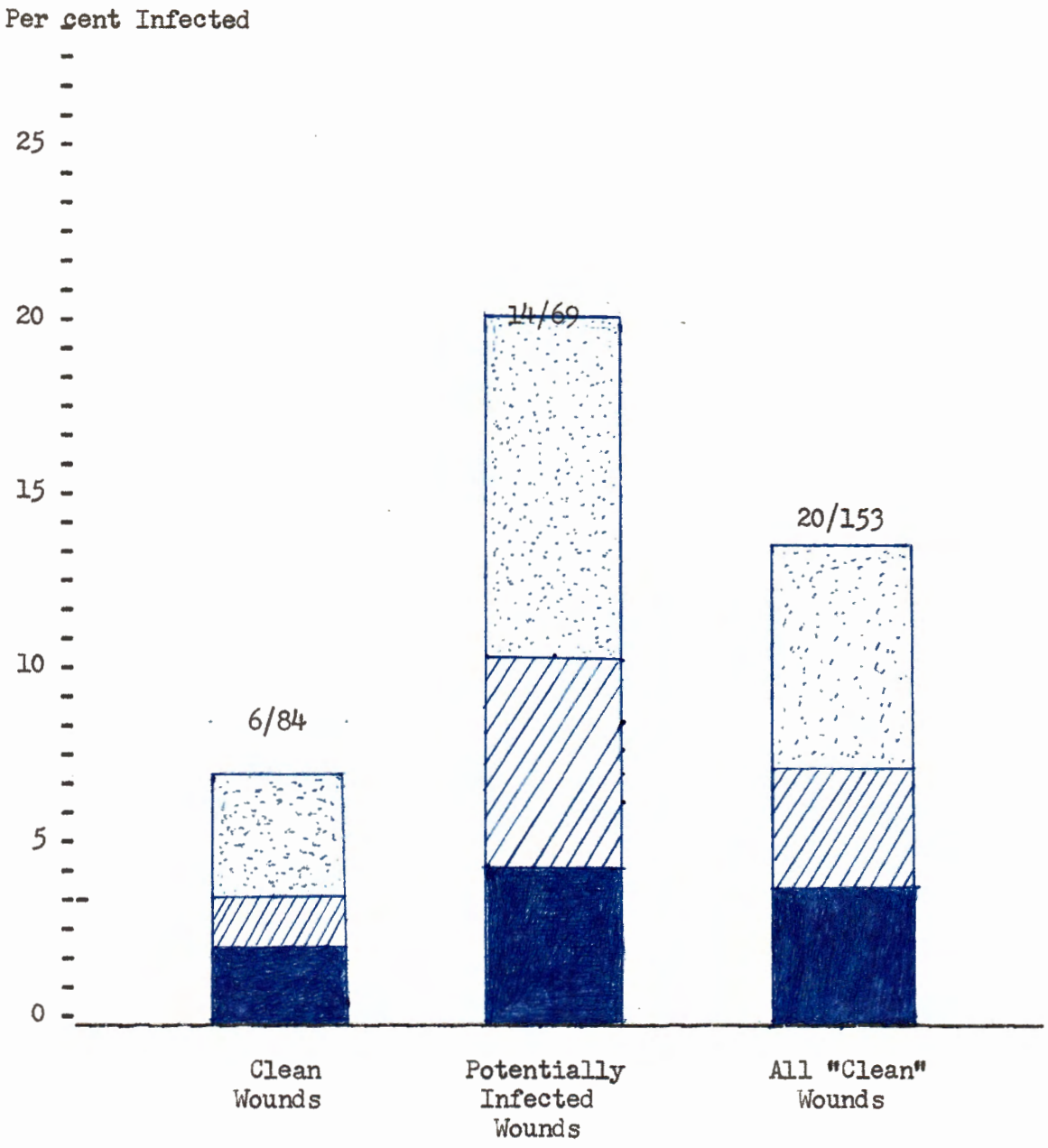

FIGURE 2

Infection in 153 "clean" wounds operated on in University of Nebraska Hospital : Stippled, mild (redness at wound edges or serious discharge) Hatched, moderate (signs of inflammation, including stitch abscess) Solid, severe (frank copious pus, systemic reaction i.e. peritonitis fistula formation).