Cystoscopy has been mentioned frequently in the course of this paper as a necessary diagnostic procedure. This will very properly raise the question as to whether it is a practicable procedure in infants and young children. One can say without hesitation that cystoscopes are made of such a fine calibre that they can be safely passed on infants, without fear of damage to the parts.

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PUERPERAL INFECTION.

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Puerperal infection includes all abnormal conditions resulting from the entrance of organisms into the genital tract during labour or the puerperium.

Puerperal infection has been recognized for many hundreds of years, and was mentioned by both Hippocrates and Galen in their works. Later, in the seventeenth century, Willis, in England, wrote a treatise on the subject as it occurred at that time. About the middle of the nineteenth century interest in this subject was aroused, as at that time about 15 per cent of all patients delivered in institutions died of this disease. Semmelweis, working in Vienna, showed that puerperal infection was identical with wound infection. Pasteur cultivated organisms from cases, and later Lister showed the value of antiseptic methods in midwifery. From this short historical survey one realizes that it was not until the latter half of the nineteenth century that our present views on this subject began to emerge.

Bacteriology.

As early as the eighteenth century it was recognized that puerperal infection was contagious. It must be remembered that at this time the death-rate from sepsis was 1 in 6 in institutions owing to the rapid spread of epidemics, which are controlled to-day by the universal use of antiseptic methods. The contagious nature of the disease was not urged strongly until Oliver Wendell Holmes read his classical paper at Boston in 1843. In this paper he showed that epidemics could always be traced to lack of cleanliness on the part of the attendants in charge of cases.

This work was not generally appreciated until as a result of the application of Lister's antiseptic methods there was a sudden fall in the number of cases infected. Much detailed bacteriology done during the whole of this present century goes to show that puerperal infection is due to the invasion of the genital tract by pyogenic organisms. As will be shown subsequently, any pyogenic organisms can give rise to infection. This is readily understood when we consider that the large raw area in the uterus, in continuity, through the vagina and open cervix, with the external surface, is comparable with any raw area elsewhere in the body. Certain organisms, such as the gonococcus, are more likely to infect the uterus than a surface wound, but taking all the known pyogenic organisms, as any one may infect a surface wound, so may any one, or more than one, infect the uterus.

Streptococci.—Streptococci may be classified as follows:

\[
\text{Streptococci} \rightarrow \text{Streptococci may be classified as follows:} \\
\text{Aerobic} \quad \text{Anaerobic} \\
\text{|} \quad \text{|} \\
\text{hæmolytic} \quad \text{non-hæmolytic} \\
\]

Schotmuller, in 1903, first differentiated between hæmolytic and non-hæmolytic streptococci, by showing that when grown on blood-agar plates, certain strains were surrounded by a clear zone of hæmolysis in which no red blood-cells were present, whereas other strains did not exhibit this property. The former are known as hæmolytic, and the latter as non-hæmolytic, streptococci.

\footnote{Working during part of the time with the aid of a grant from the Medical Research Council.}
Since then it has been the common belief that haemolytic streptococci gave rise to virulent, and non-haemolytic to mild infection.

Though this view is fairly correct in the main, a great deal of evidence has been collected to show that non-haemolytic streptococcal infection may be virulent, and haemolytic streptococcal infection may be very mild. In this hospital we have had forty-eight cases of haemolytic streptococcal infection of which none have died, and the average duration of temperature has been about eight days. Also it has been shown that haemolytic streptococci have been present inside the uterus, and the patient has had a perfectly normal puerperium with no rise of temperature. The fact still remains that puerperal sepsis, due to the haemolytic streptococcus, has a higher mortality-rate than that due to the non-haemolytic streptococcus.

The anaerobic streptococci can be grown only in an atmosphere free from oxygen. These frequently infect the uterus, as a rule giving rise to mild sepsis, which runs a long course; a temperature of 100° to 102° F. over a period of several weeks being a common result. The serious cases due to these organisms may have thrombosis of the pelvic veins. Pure cultures have been isolated from the uterus, thrombi and the blood of infected patients, thus showing that these micro-organisms are the cause of the disease. Recent work at Queen Charlotte's [1] and at this Hospital [2] goes to show that the anaerobic streptococci are as important as the haemolytic streptococci in causing morbidity.

Staphylococci.—Staphylococcus pyogenes aureus is not uncommonly found as the infecting organism; it may give rise to serious sepsis, causing the death of the patient.

Staphylococcus pyogenes albus may cause mild sepsis; in most cases the prognosis is good.

Staphylococcus pyogenes citreus rarely invades the uterus, when it does so the infection is very mild.

Pneumococcus.—This group of organisms is rarely found as the cause of infection. Figures show it to account for about 0·5 per cent. of morbidity. In this hospital, however, during the last three and a half years type T pneumococcus was found as the infection organism in two cases, both of which died in a few days.

Gonococcus.—As would be expected, the gonococcus frequently invaded the genital tract. 9 per cent. of febrile cases are due to the gonococcus, of which the larger number recover. A few fatal cases have been recorded.

Bacillus diphtheriae.—A few cases of infection with this organism have been recorded which recovered when treated with antidiphtheritic serum.

Gas Gangrene Group of Organisms.—This group contains spore-bearing anaerobic bacilli, B. welchii, Vibrion septique, B. aedematios, and a number of less common organisms. B. welchii is by far the most important in causing infection of the uterus. B. welchii is more commonly found in cases of sepsis following criminal abortion than after normal parturition; when the organism is present in pure culture, the prognosis is good, but when found in mixed culture the virulence of both organisms appears to be increased and the prognosis is doubtful. It may be remembered that in surface wound infection these anaerobic bacilli can invade the tissues only when there is massive damage which may be traumatic, chemical or bacterial, thus making conditions suitable for anaerobic growth. This fact may account for the increased virulence of B. welchii when present in association with other organisms. A considerable number of cases of gas gangrene arising from the uterus have been described, and they have generally been due to infection with B. welchii. They often show a well-marked and easily identifiable clinical picture; the patient becomes rapidly ill, develops a brick-red colour known by the
German writers as ictero-cyanosis, as it appears to be due to a combination of icterus with cyanosis due to methæmoglobin formation. The patient may have haemoglobinuræa. In some cases the gas in the uterus is detectable by percussion. The prognosis in these cases is bad. Owing to the profound toxæmia death may ensue within three days, the gas gangrene sometimes spreading throughout the body.

*B. lymphosus.*—This organism is not usually the cause of infection, it is probably present as part of the general septicæmia in early cases of typhoid fever.

*B. coli.*—Owing to the close proximity of the anus to the genital tract, contamination of the vagina is likely to follow any per vaginam examination, so that it is not surprising to find *B. coli* infections are very common, but are rarely present in pure culture. The infection usually runs a benign course, most patients recovering, though a few fatal cases have been recorded.

*Bacillary.*—Other bacilli have been found as the infecting organisms, including *B. pyocyænus*, which has been recorded as causing some fatal cases.

Diphtheroids have been found in the uterus in febrile cases, but they are commonly present in normal cases, therefore the conclusion is that this group is of little, if any, importance in causing puerperal infection.

### Pathology.

The infection may be limited to a part of the genital tract, or may spread involving the vagina, uterus, Fallopian tubes, ovaries and neighbouring structures.

**Endometritis.**—The commonest infection is one involving the uterus, giving rise to endometritis. The whole of the endometrium may be affected or only a small area; this depends to some degree on the virulence of the infecting organism.

Virulent organisms invade the uterine wall and lymphatic vessels, from there they pass to the peritoneal surface of the uterus, giving rise to peritonitis. Furthermore organisms may spread to blood-spaces, which are still numerous and large in the puerperal uterus, and eventually pass into the general bloodstream, giving rise to septicæmia.

The macroscopic appearance of the uterus from such a case shows little except some peritonitis and a ragged endometrium.

Microscopically the uterus is lined by a thin necrotic zone, deep to this a thin, irregular zone of leucocytes, which is not very clearly defined. Organisms are present throughout the uterine wall.

Mild infections of the uterus show more macroscopically, as there is usually a very definite local lesion. The uterus is bulky, containing foul-smelling material. The interior of the uterus is ragged and lined by necrotic tissue. Microscopically the endometrium is necrotic to a certain definite depth which varies in different cases; deep to this is a definite zone of leucocytic infiltration, inside this zone the uterine wall appears to be fairly normal. Organisms are seen in the necrotic area, but not in the uterine wall.

These are the two extreme pathological findings and individual cases fall into grades between these two extremes.

Another common finding is due to small collections of organisms multiplying in the uterine wall and giving rise to scattered abscesses.

Should the uterus be infected by the gas gangrene group of organisms, collections of gas in the uterine wall are commonly found. American figures from post-mortems show the following as the cause of death:—

<table>
<thead>
<tr>
<th>Cause of Death</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peritonitis...</td>
<td>43</td>
</tr>
<tr>
<td>Thrombophlebitis</td>
<td>20</td>
</tr>
<tr>
<td>Pyæmia</td>
<td>17</td>
</tr>
<tr>
<td>Septicæmia...</td>
<td>2</td>
</tr>
</tbody>
</table>

### Defence of the Body.

There is an increase in both the number and activity of the phagocytic cells and of the tissue immunity during the last weeks of pregnancy and the first days of the puerperium.
Sections through the parametrium about this time show a large increase in the number of phagocytic cells in this region.

During the first few days of the puerperium there is considerable proliferation of the connective tissue in the uterus; there is also a proliferation of the tissue phagocytes, which help to dispose of the products of involution. Should any organisms be present these cells are able to ingest and prevent their multiplying and invading the uterus or surrounding tissues. Any organisms which may get beyond the uterus are phagocytic and rendered innocuous by the reticulo-endothelial system.

It is a well-known fact that when fresh, undiluted blood is mixed with organisms then allowed to stand, the mixture becomes sterile within a short time.

Recent work in Edinburgh shows that this anti-bacterial power of the blood is much increased during pregnancy, reaching a maximum during labour, and falling to normal within the first ten days of the puerperium. The importance of this property needs no further emphasis. Should it be necessary to take blood-cultures in the puerperium, the necessity for diluting the blood as soon as possible is obvious to all.

**Ætiology.**

To recapitulate, puerperal infection is a wound infection resulting from the introduction of pyogenic organisms into the genital tract before, during or immediately after labour. The infection is usually a direct infection from without and the commonest mode of entry is on the hands, instruments or objects which come into contact with the genital tract.

**Modes of External Infection.**

The most usual way in which organisms reach the uterus is on the hands of the obstetrician or midwife. At the present time a number of individual cases and epidemics have been traced to whitlows and septic foci on the hands of the attendants, thus showing that there is still need for improvement in surgical hygiene. It is unnecessary to discuss the value of the sterilization of all instruments and dressings during delivery.

**Droplet Infection.**

Air infection is a bad term, as organisms are not free in the air but are usually present on a nidus of dust or moisture. The term droplet-infection suggests this nidus, &c., as will be shown later, in puerperal infection the nidus is probably moisture rather than dust.

The first time that the throats of students was suggested as a possible source of infection was in 1924 by two American workers. In 1927 an epidemic of puerperal sepsis due to the hæmolytic streptococcus broke out in Sloan Hospital, New York. Throat swabs were taken from all members of the nursing and medical staff and those which grew hæmolytic streptococci were sent off duty until negative swabs were obtained. Eventually no fresh cases of this infection arose in connection with this epidemic. These facts made one feel that there was some foundation for the theory that organisms present in the throats of attendants might infect the patient. It was in University College Hospital [3] in 1929 that the first case of puerperal infection was traced to an organism present in the throat of the medical attendant. The patient was a "district" case and had long labour. Two unsuccessful attempts at forceps delivery were made before she was finally admitted to hospital. The child was delivered with forceps after considerable difficulty. The patient died on the fifth day of the puerperium. Type I pneumococci were isolated from the uterus and blood-cultures but not from the sputum. Mouth and throat secretions were examined from all attendants and pneumococci were isolated from the attendants who had made the second attempt at forceps during delivery in the patient's home.
The following figures were published in a report from the Department of Health for Scotland [4]:—

13 cases of puerperal infection due to haemolytic streptococci:—

Source : 11 cases due to nose or throat of doctor.
1 case , " septic finger of doctor.
1 , " septic finger of patient.

2 cases of abortion infected with haemolytic streptococci:—

Source : 1 case due to nose of patient.
1 , " throat of doctor.

6 cases of B. coli infection:—

Source : 3 due to face or intestine.
2 , " urine.
1 , " septicæmia (? original lesion).

The identification of these organisms was done serologically.

From these it will be seen that the infecting organism probably came from the nose or throat of the attendant in 72 per cent. of cases infected with the haemolytic streptococcus. It is obvious that masks should be worn during the delivery of every patient. The efficiency of masks is open to much discussion owing to the fact that a thick mask is tiring to wear for any length of time. In this hospital a mask consisting of eight thicknesses of gauze is used, as damp masks are not as efficient as dry it is necessary to change during a long delivery.

_Blood-borne Infection._

The incidence of this type of infection is not well-known, as the primary disease is often the more important. It is possible that true uterine sepsis may occur secondary to septic foci, such as bad teeth, but the proof that infection takes place via the bloodstream is lacking.

_Autogenous Infection._

By autogenous infection one means infection of the genital tract or any part of it by organisms present at delivery. The common finding is for organisms present in the vagina before or during labour to be carried into the uterus. It may be as well to discuss here the organisms commonly present in the vagina before and after delivery in normal cases. A series of 250 cases had vaginal swabs taken on admission before a per vaginam examination had been made and again on the third day of the puerperium.

<table>
<thead>
<tr>
<th>Source of Infection</th>
<th>Before delivery</th>
<th>After delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Döderlein's bacillus</td>
<td>38'6 per cent.</td>
<td>4'2 per cent.</td>
</tr>
<tr>
<td>Diphtheroids</td>
<td>21'0</td>
<td>40'9</td>
</tr>
<tr>
<td>Coliform bacillus</td>
<td>22'0</td>
<td>46'7</td>
</tr>
<tr>
<td>Mouth streptococci</td>
<td>22'4</td>
<td>22'0</td>
</tr>
<tr>
<td>Faecal</td>
<td>14'7</td>
<td>19'6</td>
</tr>
<tr>
<td>Haemolytic</td>
<td>1'5</td>
<td>27</td>
</tr>
<tr>
<td>Anaerobic</td>
<td>0</td>
<td>4'2</td>
</tr>
</tbody>
</table>

The figures for the incidence of the anaerobic streptococci are incorrect owing to lack of experience in factors necessary for their growth. There is a large increase in the incidence of coliform bacilli after delivery, which suggests faecal contamination of the vagina. The slight increase in the incidence of haemolytic streptococci is of little importance, as the actual number of cases was small. No case with haemolytic streptococci present in the vagina before delivery became infected.

Twenty-one cases of sepsis in which the bacteria present in the vagina before delivery had been fully worked out, showed that autogenous infection had occurred in four. Two cases of _B. coli_ infection had _B. coli_ in the vagina before delivery, likewise two cases of non-haemolytic streptococcal infection. These cases were very mild.

It is well known that the uterus of pregnant and non-pregnant women is sterile. In normal cases immediately after delivery the uterus is sterile, about the third day of the puerperium organisms can be isolated from it in 50 per cent. of normal cases showing no signs of infection.

_Frequency._

Before the use of antiseptic methods the mortality from puerperal infection in institutions was 10 to 15 per cent. of all cases delivered, these figures have dropped to 0'15 per cent. As the present figures are so small it is common to use a morbidity rate, which attempts to give the number of cases infected. The British Medical Association
standard of morbidity is: "A temperature above 100° Fahrenheit, occurring on any two occasions between the end of the first thirty-six hours and the end of the eighth day, recorded on a 1/4-minute thermometer, which must be placed in the mouth for a period not under three minutes."

On looking through past records it is disappointing to find that the incidence of puerperal infection is about the same as it was forty years ago. This fact suggests that there must be a source of infection which was not known. It is possible that the use of masks by all attendants present at delivery will cause a fall in the morbidity rate.

SYMPTOMS AND SIGNS.

The most important sign of sepsis is an increased temperature or pulse or both. Very often there is little else of note, though, as one would expect, the patient usually complains of headache with the raised temperature.

When the infection is virulent the lochia are usually decreased and the pad is practically odourless. The uterus does not involute or else involutes slowly.

With less virulent infections, where the uterus is lined with necrotic material, the pads are stinking, there is an increase in the lochia. The uterus is bulky and tender.

From these two extremes it will be realized that stinking lochia is a favourable sign rather than otherwise. The lochia may become infected in the vagina, causing the early morning pad to have an unpleasant odour, this is found in many normal puerperia and is not therefore a sign of uterine sepsis.

In cases of infection due to the gonococcus the first five to seven days of the puerperium are usually normal, then the temperature rises to about 100° F., remains up for about a week, then drops. There are often no symptoms whatsoever. In spite of this the patient is often left, with a chronic cervicitis and possibly other chronic infections as well. There will be further symptoms should the infection spread to the broad ligament, tubes, &c.

The appearance of the patient is much the same as the appearance in any other infection elsewhere in the body.

In cases of hemolytic streptococcal infection the patient looks hectic, the pulse is fast and easily compressed. Rigors may occur in infection with any virulent organism, they are common with haemolytic streptococcus and B. coli.

One has to be reserved in giving a prognosis in cases infected with haemolytic streptococcus, as they are very liable to relapse and have rigors even after some days of normal temperature.

DIAGNOSIS.

In a well-conducted hospital puerperal sepsis is a rare disease and the same should be true of general practice. A careful general examination of each patient is necessary before presuming her to be a case of puerperal infection. Of 125 morbid cases only forty-eight were shown to be due to genital sepsis, therefore only one third of patients with temperature are due to sepsis in this hospital. In genital sepsis one includes temperature due to septic tears of the perineum. It must not be forgotten that a tear with necrotic material on the surface and surrounding oedema is very likely to cause some rise of temperature.

Lochia.

It is not justifiable to state that a given patient is certainly septic until intra-uterine cultures have been made. In practice it is usually impossible to do this, but in that case one presumes a patient to be septic. In this hospital cultures are taken by Foulerton and Bonney's method, as follows:—

"The apparatus consisted of a cotton-
wool swab on a long flexible metal rod inside a curved glass tube closed at the end by a gauze plug attached to a string loosely wound round the outside of the tube in its entire length, and at the opposite end by a cotton-wool plug through which the handle of the swab projects. The whole is sterilized in a copper box. The external genitals were carefully swabbed with antiseptics, the cervix brought into view through a speculum and then swabbed with dry sterile gauze. The glass tube was then passed through the cervical canal into the uterus and the gauze plug dislodged, when the swab was projected into the uterine cavity, withdrawn into the bent tube, removed and placed in a sterile test-tube."

As few uteri are completely sterile after delivery it is important to make cultures on solid media in order to get some idea as to the number of organisms present. In cultures from a septic case the growth is usually confluent, in non-infected cases there may be a few colonies.

The finding of haemolytic streptococci in the uterus does not necessarily mean a bad prognosis. The Americans show that of eighteen patients infected with haemolytic streptococci only one dies.

**Blood-culture.**

Where possible it is wise to take a blood-culture from all patients with a temperature of over 101° Fahrenheit. About 10 c.c. of blood should be taken, citrated, then diluted with broth and incubated.

One positive blood-culture is not of any great significance, but, repeated positives usually mean a bad prognosis. The blood should be taken while the temperature is rising, or, according to the textbooks, during a rigor, as it is often positive only at these times.

Where positive blood-cultures are found together with evidence of thrombosis of the pelvic veins the prognosis is bad.

**Treatment.**

The treatment will be discussed from a bacteriological point of view, omitting all surgical procedures.

The most important point is prophylactic treatment. To recapitulate, puerperal infection is a wound infection, and so is due to the introduction of organisms. From this it follows that surgical cleanliness on the part of the attendants is the most important point. Attendants conducting a case should wear sterile gloves and rinse them in antiseptics at frequent intervals.

From the figures on the number of cases infected by nose and throat carriers of haemolytic streptococci it is obvious that masks are always necessary.

It is most unwise to do any high vaginal douching or swabbing with antiseptics before delivery, as it has been found that at this time there are very few organisms present there and douching increases rather than diminishes the number. It is important to wash the vulva with soap and water and then with some antiseptic before doing per vaginam examinations as one does not wish to introduce more faecal organisms than necessary. In this hospital chloramine T—1 in 100 solution—is used, as it is thought to be more efficacious on mucous surface than other antiseptics. From the fact that autogenous infection is rare and mild, ordinary surgical cleanliness is all that is needed.

It is probable that infection usually occurs during parturition. As cases may be infected during the puerperium, bed pans should be sterilized before use; where this is impossible, separate ones should be kept for each patient and sterilized between cases.

**Serum.**—Experimental findings go to show that haemolytic streptococci may vary serologically, as their particular protein make-up may differ, but the toxin produced is the same. The amount of toxin produced by different strains varies. As the scarlet streptococcus forms more toxin than strains isolated from other diseases it is able to
produce a more potent antiserum when injected into an animal. These anti-
haemolytic streptococcal sera are anti-toxic, their anti-bacterial powers, however, are
probably not great.

In cases of puerperal sepsis due to the haemolytic streptococcus it is the organism
itself which causes the disease, the streptococcus multiplies in the uterus, invades the
uterine muscle and gets into the bloodstream, the whole picture is one of invasion
by the streptococcus itself. This explains why the use of anti-streptococcal serum has
not been very satisfactory. The cases of puerperal fever in which the lesion can be
ascribed to the actual toxin of the streptococcus are very few. There was a case
admitted to this hospital in January which had haemolytic streptococci in the uterus
and a scarlet rash, her symptoms were apparently due to the toxin of the strepto-
coccus and she was improved by anti-streptococcal serum. The vast majority of
cases are due to invasion by the haemolytic streptococcus, and the anti-streptococcal
serum does not appear to have any very great effect on this property. Nevertheless,
as our knowledge stands at present, in bad cases of infection serum is indicated.

The usual dose is 20-30 c.c., either subcutaneously, intramuscularly or intra-
venously. In bad cases the later method should always be used. Great care should
be exercised in the giving of antistrepto-
coccal serum, particularly if the intravenous route is used as the volume introduced is
considerable. Therefore in giving antistreptococcal serum one is giving a great
deal of a foreign protein and is much more likely to get toxic symptoms due to the
horse-serum itself. One must emphasize the importance of testing the sensitivity of
any patient to the serum before giving a full
dose. Should collapse occur after the serum,
0.1 c.c. of adrenalin made up to 1 c.c. with
sterile water and injected intravenously can
be relied upon to relieve urgent symptoms
of an anaphylactic type. It is necessary to
have syringe and tourniquet ready in case of
accidents.

It is not justifiable to give serum unless
necessary, as the operation itself is never
completely without risk, also it is unfair to
sensitize a patient to horse-serum unless
absolutely necessary.

Blood-transfusions should be given as a
prophylactic to cases in which there has
been ante-partum or post-partum haemor-
rhage and one suspects that the patient may
become infected. Cases of long-continued
fever usually show a lesser or greater degree
of anaemia, and blood-transfusions in these
cases are often beneficial.

The use of drugs intravenously has always
been disappointing, arsenic and mercury
compounds and dyes have been tried, but
without any encouraging results.

Vaccines have been used prophylactically
and in the treatment of the acute disease.
Figures do not suggest any good results
from such treatment. There is no very
convincing evidence from experimental
work on animals that haemolytic strepto-
coccal vaccines increase the immunity to
this organism.

The introduction of sterile glycerine into
the uterus is often beneficial [5]. A rubber
catheter is introduced into the uterine cavity
with strict aseptic precautions; to the
catheter is attached a syringe containing
10-20 c.c. of sterile glycerine, which is then
injected slowly. The glycerine promotes a
flow of tissue fluid owing to its hygroscopic
property, thus giving a freer uterine drainage.
Experience in this hospital suggests that
this treatment gives good results in cases of
patients with persistent fever due to infection
localized to uterus and adnexa.

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Puerperal Infection

Joan Taylor

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