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THE HISTORY OF THE PREVENTION OF PUERPERAL FEVER*

BY

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This title having proved too ambitious a one for a lecture of an hour's duration, I have found it necessary to restrict my subject to a theme which can be indicated by the following words from Geoffrey Chaucer's *Canterbury Tales*—the words, written in 1389, with which the Manciple admonishes the drunken cook:

"Hoold cloos thy mouth man
Thy cursed breeth infecte wole [will] us alle."

Consideration of the study of the development of a therapeutic or a prophylactic measure will often be found to strengthen our intention to employ the measure in question.

The Principle of Contagion

The history of the prophylactic measure which I shall later on advocate may be held to begin about the middle of the nineteenth century. At that time a fundamental principle, that of contagion, was at last accepted by most of the leading obstetricians of the day. This theory had been long since suggested by Alexander Hamilton, in 1781, demonstrated by Alexander Gordon, in 1795, and more recently supported by Oliver Wendell Holmes, in 1843. It suits my purpose to cite only one of these converted authorities, one who had already conferred a great boon on parturient women by the introduction of chloroform.

In the discussion which followed a paper on puerperal fever read by Dr. Arneth of Vienna before the Medico-Chirurgical Society of Edinburgh on April 16, 1851, Dr. James Y. Simpson said: "But in this country we do not believe that the disease is usually propagated directly from individual to individual, but indirectly, through the medium of a third person; and that person generally the medical attendant or nurse." In the same speech Simpson confesses that in 1836, when he had his first experience of puerperal sepsis in his own practice, he had "no full and proper belief in the contagious propagation of puerperal fever." Otherwise, he leads us to infer, he would not have gone from active participation in necropsies in two cases of fatal puerperal sepsis to four cases of midwifery, all of which became infected.

It should especially interest a Manchester audience, and particularly those who are members of the staff of St. Mary's Maternity Hospital, to hear or recall that Simpson had been not a little influenced by reading an account of an outbreak of puerperal sepsis in the district maternity practice of the Manchester Lying-In Charity—the forerunner of the present-day St. Mary's Maternity Hospital. Simpson had read of this in a letter published in the *London Medical Gazette* in 1832—under the heading "Is Puerperal Fever Infectious?"—by Dr. John Roberton.

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Dr. Roberton was appointed to the hospital staff in 1827, and he was the last member to bear the title of man-midwife, this being changed to surgeon in 1828. His letter had been written in response to a communication to the *Gazette* by Dr. William Campbell, and it is advisable to quote directly from it, as Simpson, apparently trusting to memory, is inaccurate in not a few of the figures he gives. Dr. Roberton begins thus:

"Sir,

"The letter of Dr. Campbell on puerperal fever, which appeared in the *Medical Gazette* of December 10, has recalled my attention to certain facts in my possession, calculated to throw some light on the query which heads this communication.

"On the question of infection' (Dr. Campbell observes) 'I am as much as ever impressed with the belief that unless the practitioner has been engaged in the dissection of the bodies of those who have fallen victims, the disease cannot be conveyed by him from females labouring under it to others recently delivered; but if he have been so engaged, I have strong reasons for believing that he may be the means of propagating it.' My experience," Roberton comments, "is not in unison with this conclusion. On the 4th of January last [1831] a meeting of the medical officers of the Manchester Lying-in Charity was summoned in consequence of a great mortality having occurred, during the four preceding weeks, among the patients of one of the midwives. The circumstances we found to be these: Mrs. A. B., a midwife in great practice among the patients of the Charity, had on the 4th of the preceding month delivered a poor woman, who soon died with symptoms of puerperal fever. From this date to the 4th of January inclusive—exactly one month—this midwife delivered thirty women residing in different parts of an extensive suburb, of which number sixteen caught the disease, and all of them ultimately died. These were the only cases of puerperal fever which had for a considerable time occurred in Manchester. The midwives, commonly twenty-five in number, deliver, on an average, ninety women per week. Now of this number delivered during the month in question, none had puerperal fever except the patients of Mrs. A. B. Yet all this time this woman was crossing the other midwives in every direction, scores of the patients of the Charity being delivered by them in the very same quarters where her cases of fever were happening. . . .

"The decision of the medical officers of the Charity was to the effect that Mrs. A. B. should abandon her practice for a short period, and go into the country."

Dr. Roberton concludes:

"The fact that sixteen cases of puerperal fever occurred in one month in the practice of a single midwife, while the patients of the other midwives were exempted from the disease, leads naturally to the conclusion that this midwife was the *medium* of communicating (I take not upon myself to say in *what manner*) the malady from one woman to another—from one affected with the fever to another in health."

The modern conception of a carrier had not of course been considered in those days. Within the last few years I myself have taken a small part in the investigation of two similar epidemics in the practices of one only of each of two groups of midwives—both of whom had clean records for several years. In each epidemic it was clear that some of the patients were infected during the puerperium and not at the labour. In each instance haemolytic streptococci were found in the throats of the midwife, and both were cured by removal of the diseased tonsils.

Simpson came to the conclusion that the unfortunate midwife in question must have been, unlike the other midwives, "connected with some form of that morbid principle or virus to which pathologists give the name contagion." No one at that time had any conception of the nature of that virus. Some even held it could never be known. Charles Meigs of Philadelphia, a bitter opponent of Oliver Wendell Holmes's views, wrote in his *Treatise on Obstetrics*, 1856:

"The student will naturally be desirous to learn, if childbed fever be really a contagious disease, what the principle of that contagion is; and I apprehend that here he shall have to rest content with the *sound* of the word contagion, a word which, being interpreted, means communicable from person to person, or by individual to individual. This is the whole meaning of the word; for, as to how, and the what, no man hath yet obtained the least definite notion, since no man hath known or can know what a miasm or a contagion is. Miasm and contagion are words, nothing more: they represent no precise material idea of the mind."

Dr. Robertson's account of the Manchester epidemic had been previously cited by Oliver Wendell Holmes (1843).

The High-pressure Sterilizer

It is also of great interest to record that John Robertson played a small part in an investigation which led to the invention of the high-pressure sterilizer, so essential to modern aseptic technique. Dr. William Henry, the famous physicist (1775-1836), also of Manchester, was making experiments on sterilization by heat, at the request of a cotton importer, in the hope of preventing the introduction of plague in cargoes of Egyptian cotton landed at Manchester. Dr. Henry (1831) states that "the most important point to be ascertained, and that on which the utility of the inquiry hinges, is whether temperature below 212° Fahrenheit is capable of destroying the contagion of *fomites*." To test the effect of different temperatures, for varying periods of time, Henry made use of fresh vaccine lymph. Among others, Dr. John Robertson, "one of the surgeons of the Manchester Lying-In Hospital," supplied Dr. Henry with the vaccine lymph. The double-jacket steam sterilizer was devised as the direct result of these experiments.

Thus this powerful means of destroying the cause of contagion was invented and in use thirty years and more before it was proved that the actual fomites were the micro-organisms of Anthony van Leeuwenhoek, microscopic protozoa which he had discovered—in water in 1675, and, in 1681, in material from the human mouth. It was ignorance as to the nature of these fomites—of the "precise material" of Charles Meigs, of the body or substance which could be conveyed by a third person from one patient to another—that had long delayed the wide acceptance of the theory of contagion. The final acceptance had been actually based on circumstantial evidence alone.

Years were to elapse before the elusive and, as it proved to be, microscopic malefic object was discovered,

although, one is amazed to find, the transcendent brain of William Harvey had in 1651 used the term "fomes" and had conceived the idea of "seeds of epidemic and contagious diseases" which "propagated to a distance through the air," and "in a hidden fashion silently multiplying themselves by a kind of generation . . . spread destruction far and wide among man and beast."

Skoda of Vienna, inspired by the theory of Semmelweis that poisonous animal matter was introduced by the hand of the accoucheur into the genital tract, suggested to Semmelweis in 1849 that the problem should be investigated by experiments on animals. By means of a brush at first, later a syringe, exudate from a case of endometritis, or pus from an abscess, was introduced into the vagina and uterus of rabbits recently delivered. Later the post-mortem appearances were studied, but in the absence of microscopical examination nothing of real value was learnt.

The Indictment of Bacteria

It was Louis Pasteur who initiated the investigations which were to lead to the indictment of bacteria or microbes as the long-desired *materia peccans* of contagion. The study of diseases of grapes, of silkworms, of cattle, had fired his imagination to "arrive at the knowledge of the causes of putrid and contagious diseases" in human beings. After investigating septic cases in the surgical wards of hospitals he studied cases of puerperal infection in the Maternité, finding in certain of them "a microbe in the shape of chain or chaplet, which lent itself very well to culture."

The description by Monsieur Roux of an occasion (March 11, 1879) on which Pasteur proclaimed this discovery is well worth recalling to our minds. "One day, in a discussion on puerperal fever at the Academy, one of his most weighty opponents was eloquently enlarging upon the causes of epidemics in lying-in hospitals: Pasteur interrupted him: 'None of those things cause the epidemic; it is the nursing and medical staff who carry the microbe from an infected woman to a healthy one.' And as the orator replied that he feared that microbe would never be found, Pasteur went to the blackboard and drew a diagram of the chain-like organism, saying, 'There, that is what it is like!'"

He had found streptococci in the lochia of dying patients and had cultivated them from the blood, taken both before and after death. This was a discovery which must have undermined the opposition of any remaining anti-contagionists, and one can appreciate the satisfaction with which Oliver Wendell Holmes, writing to Dr. Chadwick in 1883 on the contagiousness of puerperal fever, is able to boast: "But I shrieked my warning louder and longer than any of them, and I am pleased to remember that I took my ground on the existing evidence, before the little army of microbes was marched up to support my position."

The new science of bacteriology thus arose, and was ardently pursued by a rapidly increasing army of investigators in all civilized countries. Other organisms were discovered, isolated, and proved to be the cause of rarer types of puerperal infection, most of which were much less severe and less frequently fatal than that caused by the streptococcus.

It is impossible, and really unnecessary for my purpose, to review the story of the discovery of these various organisms. This was admirably done by Arnold W. W. Lea (1910), also a member of the surgical staff of St. Mary's Hospital. The list he gives still stands: in

addition to streptococci it includes staphylococci, the colon bacillus, pneumococci, the gonococcus, the bacillus of diphtheria, of tetanus, of typhoid even, the *Bacillus aerogenes capsulatus* of Welch, and the *Bacillus pyocyaneus*.

The Introduction of Antiseptics

The discovery of bacteria was quickly followed by Lister's introduction, in 1867, of the chemical antiseptic with which microbes in septic wounds or on the skin of the patient or the hands of the surgeon could be rendered inert. Lister, employing the method with meticulous care, was soon able to revolutionize surgical operative practice. Certain obstetricians—and one must mention Hayes of the General Lying-in Hospital, London, and Tarnier of Paris—convinced of the identity of surgical and puerperal sepsis, introduced antiseptics into their midwifery practice, with a striking reduction in the occurrence of infection in the maternity hospitals they controlled. However, we must not forget that many years previously Robert Collins of the Rotunda (in 1829) and Semmelweis in Vienna (in 1847) had used a solution of chloride of lime to destroy the unknown virus of infection.

The use of antiseptics soon became the first line of defence in the campaign against puerperal sepsis, and so it remains to this day. Many forms have been introduced since the days of Lister's carbolic acid. The search for the ideal antiseptic has a story of its own, which some consider is not yet complete; many others are perfectly satisfied with the one of their choice.

Although the incidence of puerperal sepsis has been greatly diminished, the dread disease has by no means been eliminated. Sporadic cases are of not infrequent occurrence, and even epidemics occur in hospital as well as in private practice. Puerperal sepsis is still one of the chief causes of puerperal mortality. Some authorities maintain that this is only the consequence of the neglect or the inefficient use of the antiseptic ritual. Others, doubting this simple solution of a grave problem, have with infinite pains searched more and more deeply into the life-history of the microbes chiefly concerned, and particularly into their habitat—the lair in which they must be destroyed or between which and the woman in labour an effective barrier must be set up. Since Pasteur's day it has been recognized that streptococci cause the great majority of the serious and fatal infections. They have been intensively studied by devoted specialists, and gradually the complexity of the nefarious clan has been revealed. Streptococci are subdivided according to the way in which they grow: some are haemolytic, others have no action on blood, while others will only grow in the absence of oxygen. Of the haemolytic strains only one group (Group A) is capable of causing severe infection in human beings, and this group is further subdivided by intricate serological means into about twenty-five distinct types. Some half of these known types have been found to play a causative part in puerperal infections.

The history of these investigations is beyond my purpose and, indeed, my powers. I have chosen to attempt to unravel the story of the tracking of the villain to his chosen lair and the provision of a means to intercept him at its exit. I refer, of course, to the human throat and the surgical face mask.

The source of the problematical virus had for long been a matter of speculation, the most favoured being decomposing animal matter associated with necropsies and dissections, cancers, and surgical wounds, especially where

midwifery cases and cases of general disease were housed under the same roof. Semmelweis and Holmes both laid down rules of conduct against these dangers. The means of conveyance were debated; clothes, the hands, the atmosphere were accused.

Charles Meigs, the anti-contagionist already quoted, ridiculed the idea: he tells of

"another friend of mine who had been chased, so to speak, by a series of such cases, seventy in all, left the city, was absent many days, and on returning, shaved his head, got a new wig, new clothes, new gloves, new pencil. He went into a bath, was washed clean, dressed himself, and then visited and assisted a woman in labour who was seized next day and died." If the man "was poisonous," says Meigs, "how was he so? Everything except the man was new. He could not have carried the atmosphere of his last patient's chamber with him to the country, keep it about him like an invisible cloud," and "then carry it into the last patient's chamber to destroy her with exhalations more pestiferous than the breath of Cacus."

By the irony of fate Meigs's satirical flights of imagination had brought him near the truth: the "new pencil" wetted by the lips might have infected the doctor's fingers; the "exhalations more pestiferous than the breath of Cacus" may well have conveyed virulent streptococci. In fact this was so; for Meigs's friend was no other than the unfortunate Dr. Rutter of Philadelphia, who within five years had ninety-five cases of puerperal infection in his practice, with eighteen deaths. It is known that he suffered from ozaena due to chronic rhinitis.

Many years later, in 1924, two outbreaks of pyrexia at the Portsmouth Municipal Maternity Hospital were proved to be associated with the presence of a pupil midwife who suffered from atrophic rhinitis and in whose nose haemolytic streptococci were found.¹

Relation of Streptococcal Sore Throats to Puerperal Fever

The discovery of microbes gradually led to the eclipse of mere conjectures; theories could henceforth be scientifically tested. The comment of Dr. John Clarke (1793)—that "it is a curious circumstance that before the attack of the epidemic of lying-in women at Paris in the year 1746, in the month of January, there had been an epidemic low fever, with an ulcerous sore throat"—has thus been illuminated by the discovery that certain members of Group A of the haemolytic streptococci can be much more readily found in human throats at the time of year when puerperal sepsis is most prevalent. Alexander Gordon, who wrote in 1795 on the "Epidemic Puerperal Fever of Aberdeen (1789-92)," prepared a set of tables showing the simultaneous prevalence of "inflammatory sore throat." Fleetwood Churchill (1849) speaks of the "epidemic season," between November and May, and shows that the eighteenth century writers on puerperal sepsis—Leake, Armstrong, Campbell, Hey, Joseph and John Clarke—all agreed that the "puerperal fever prevails most during the winter and spring months."

Although streptococcal sore throats are most prevalent from October to May, demanding specially careful precautionary measures in surgical and midwifery practice, they may occur at any season, and so the same precautions are actually always desirable. In my quest for the discoverer of this source of contagion I arrived at a paper by W. Hübener (1898) based on experimental work carried out at the Breslau Surgical Clinic of Professor Mikulicz. Hübener begins by referring to the pioneer work of

¹ *British Medical Journal*, 1924, 2, 623.

Flügge, reported in 1895. Flügge had not only proved that the micro-organisms found in the human mouth might be pathogenic, but had demonstrated the "surprising and extraordinarily important fact" (to use Hübener's own words) "that when speaking, coughing, and sneezing a spreading about of the mouth and nose secretions takes place. Even at a distance of several metres he had shown that agar plates were covered with colonies after somewhat louder and livelier speaking." Flügge urged the exclusion from aseptic operations of all persons suffering from acute catarrh.

Mikulicz, searching for an "absolutely germless" surgical technique and at this time experimenting with sterilized thread gloves, was deeply concerned by this newly recognized source of infection. He immediately set to work to parry it. In July, 1897, he described the "Mundbinde" (mouth bandage) which he was using for this purpose. This is, I believe, the first publication on the subject. The material used was the finest mull, "sterilized of course," he says, and "fastened to the similarly sterilized operation-gown."

Although Mikulicz claimed that he had quickly become accustomed to their use and "could breathe through them as easily as a lady who in the street wears a veil," we find that he had asked Hübener to search, by experiment, for a comfortable as well as a secure means of protection. In his lengthy paper Hübener describes his method of experimentation. An assistant whose mouth had been thoroughly rinsed with a diluted culture of *B. prodigiosus* spoke and coughed, at varying distances and angles, over appropriately arranged agar plates. The green colour of the prodigious colonies made it easy to distinguish the germs "spoken out from the oral cavity" from those deposited from the air.

Evolution of the Face Mask

These experiments led to the gradual evolution of a metal frame—a modified Esmarch chloroform mask—with spectacle ear-pieces, carrying a double layer of close-meshed mull. As evidence of the exhaustive character of these pioneer experiments it must be noted that Hübener demonstrated that the mask should be held at a distance of a few centimetres from the mouth, and this not for comfort only but to increase its efficiency as a filter. This is a requirement which is ignored in most types of mask, but it can be easily achieved by giving a snout-like projection, by means of a stiffened dart on each side of the simple oblong of folded gauze so much in use.

Concurrently with the investigations of Mikulicz and Hübener the problem was being studied in Paris. The famous surgeon Paul Berger read a paper "On the Use of a Mask in Operating" before the Surgical Society of Paris on February 22, 1899. He began with the statement: "For several years I have been worried as to the part that drops of liquid projected from the mouth of the operator or his assistants may exercise on the outbreaks of infection which one still sees from time to time under conditions of surgical asepsis which are apparently satisfactory." Berger's suspicions had been aroused by the association of a short series of cases of suppuration in clean operations with an assistant who was suffering from an alveolar abscess. The same mishaps occurred several months later, when he himself was suffering from a dental periostitis. His attention directed to the point led him to notice that drops of saliva were projected from the lips of the operator or his assistant even when isolated words, orders in monosyllables, were given.

Aware of Flügge's discovery of the presence of pathogenic bacteria in the saliva, he had set to work to find a means of "shielding his operation wounds from this cause of contamination," even before Mikulicz had published his paper. In October, 1897, he began to wear a rectangular compress of six layers of gauze, sewn at its lower edge to his sterilized linen apron (he had a beard to safeguard) and the upper border held against the root of the nose by strings tied behind the neck. His investigations appear to have been purely clinical, but in the course of fifteen months he convinced himself that he had markedly diminished the incidence of sepsis after clean operations. His paper ends thus:

"It is exactly because I realize that perfection in the carrying out of operations aseptically must not concern itself with any one point but with all, and must neglect no detail, that I have been so anxious to insist on a precaution, the use of which has contributed not a little to improve my operative results. I do not blind myself to the fact that this is too great a shock to custom for it to receive a much more favourable welcome than that accorded by the German surgeons to an analogous communication by Professor Mikulicz."

His surmise was correct: in the discussion that followed a Monsieur Terrier scoffed at the proposal, saying, "I have never worn a mask, and quite certainly I never shall do so." However, in time surgeons did adopt the precaution, and probably the first English surgeon to insist, in a textbook, on the use of the face mask was that master of operative technique Berkeley Moynihan in his *Abdominal Surgery* (second edition, 1906). He pours ridicule on the scoffers "who claim to be satisfied with their results."

Berkeley and Bonney in their *Textbook of Gynaecological Surgery*, first issued in 1911, after testing by experiment the validity of the danger, stated their conviction that the surgeon and his staff should wear masks. Yet in their work *Obstetrical Emergencies*, even in the third edition of 1921, they do not mention the possibility of droplet infection. This illogical position was indeed shared by all, or nearly all, of us who have during the last twenty years practised both gynaecology and midwifery.

The Pioneer in the Use of the Mask

In seeking the pioneer in the use of the mask in obstetric practice I have come to the conclusion that Professor Benjamin DeLee (known at the moment to the American lay press as "Number One Obstetrician, U.S.A.") is entitled to the credit for this.

Let me tell the story in DeLee's own words, from a recent letter:

"I cannot say just when I first started to use face masks in obstetric practice. I believe it was certainly at the same time, or even before, the surgeons used them.

"Just about the turn of the century we had a small epidemic of puerperal infection among the mothers and the babies at the Chicago Lying-in Hospital Dispensary, the home service, which of course was astonishing.

"On investigation I found that one of the interns, who liked to teach and demonstrate to the students while he was delivering the women, had a slight salivation and little tiny droplets of saliva were present frequently at the corners of his mouth. All of the cases that got sick were handled by this particular intern, and one mother and one baby died of streptococcus infection.

"I made a careful study of this intern's nose and throat and found a short-chain streptococcus. I relieved him from service and gave him a position in the laboratory of a South

Side hospital. The epidemic ceased abruptly and we have had no trouble in this regard since.

"I immediately instituted rules and regulations regarding talking on obstetric cases (such as averting the face when talking over a patient so as not to spit upon her, keeping the hands away from the face and mouth while on duty so as not to infect them with saliva, not to attend a labour case if suffering from a head cold or sore throat, etc.), but I do not remember that I insisted on masks.

"The first record that I have of the use of masks is in 1907 while I was preparing the third edition of my book on obstetrics for nurses, which was published in 1908. There is a picture in this book of the doctor aiding the parturient to bear down, and he wears a face mask."

The first protection used by DeLee was "a thick scarf of cheese-cloth." Finding that spittle could be driven through the mesh of this he used thick towelling, and this again he fortified with a four-inch square of adhesive plaster during epidemics of colds or if he himself had a sore throat and had to continue at work.

Kanter and Pilot (1924) appear to have published the first account of a bacteriological investigation of the likelihood of droplet infection in obstetrical practice. It was carried out in the extern department of the Presbyterian Hospital, Chicago. They found "no evidence to support auto-infection from vaginal streptococci," but concluded that "droplet infection from attendants is possible and that the use of masks during delivery and the exclusion of those having sore throats from the delivery room and from attendance on puerperal women is clearly indicated."

Delay in the Use of the Mask

Apart from its use in Caesarean section there has been an astonishing delay in the employment of the face mask in hospital and, even more so, in domiciliary midwifery practice. It is sad to reflect that its adoption or more rigid use in this or that institution, on this or that maternity district, has so often been and still is the direct consequence of an epidemic, more or less rapidly controlled, in the hospital itself. It would appear that some even await the stimulus of legal proceedings.

Investigation into Hospital Epidemics

Many such epidemics have been laboriously investigated by bacteriologists especially skilled in the recognition of the various types of streptococci. It is only in this way that the origin or the originator of the epidemic or of the sporadic case can be detected and indicted with a degree of probability almost amounting to certainty. The first of these thoroughly investigated epidemics was that which occurred in the Sloane Hospital, New York, in January and February of 1927. Of 163 delivered women twenty-four (15 per cent.) developed haemolytic streptococcal infections; eight of these died. It was fully reported in the August number, 1928, of the *American Journal of Obstetrics and Gynaecology* by Professor B. P. Watson and Dr. Frank Meleney. A complete bacteriological examination of the hospital failed to demonstrate haemolytic streptococci in the air, on the floor or walls, in the operating room, in dressings, supplies, or water. The only place where streptococci were found, other than in the infected patients, was in the nose and throat of certain doctors, nurses, and members of the domestic staff. In the summary of these papers it was laid down that it is "important to exclude streptococcal carriers from maternity hospitals and to insist on complete masking by all in attendance on parturient and puerperal women." Thus one result of

this epidemic was the much more rigid masking of both mouth and nose.

The Sloane Hospital Report aroused widespread interest in a source of infection which, as we have already seen, had been suspected by a few for years but had never before been strongly attested. The report was reviewed and warmly welcomed by Professor DeLee in the section of obstetrics of "The Practical Medicine Series" for 1928. At last he had powerful scientific support for the complete masking of mouth and nose, which he had already been employing and advocating in midwifery practice—against much opposition—for no less than twenty years.

In June, 1929, Nixon and Wright reported two fatal cases of pneumococcal septicaemia during the puerperium from University College Hospital, London. The second patient was a hospital "district nurse." By serological tests it was found that the throat of one of her attendants (who was suffering from a severe "cold") yielded pneumococci of the same type—Type I—as the vagina, uterus, and blood of the woman. This is, I believe, the first case recorded in which the bacteriological evidence attained such a degree of probability. As a consequence face masks, which had been used at deliveries within the hospital since early in 1927, were made compulsory on the district.

Just one more instance of a compelled change of policy. In the early months of 1936 one of the most famous maternity hospitals in the world, the Rotunda (see Annual Report), experienced an epidemic of streptococcal sepsis; four out of fourteen cases ended fatally. This coincided with a severe outbreak of streptococcal throats among the hospital staff and in the city. A full investigation was made, and among the conclusions we read: "Up to this time masks had not been used in the maternity department, but this epidemic and the knowledge of the mode of origin decided a change of policy."

Other Investigations

Many similar investigations have been made since 1928. It is impossible to enumerate or analyse them. However, I believe that all authorities would wish to give a special recognition to the work of Dr. Leonard Colebrook. In a chat with Professor DeLee in Chicago last autumn I was asked to convey the Professor's personal gratitude to "the Colebrooks" for their work on the sources of infection in puerperal sepsis. Dr. Leonard Colebrook has summarized this work; referred freely to that of others; and given his own conclusions in *The Prevention of Puerperal Sepsis*, published in 1936. This should be carefully studied by everybody—midwife, accoucheur, and administrator—concerned for the safety of childbirth.

In 1925 puerperal sepsis was the chief subject for discussion at the British Congress of Obstetrics and Gynaecology, held in London. The possibility of droplet infection was not even mentioned. Professor Whitridge Williams, who took part in the discussion, was impressed by the fact that in a series of streptococcal infections in his service 30 per cent. of the patients had had spontaneous labours without even a vaginal examination: this is a generally accepted proportion. He thought that all bacteriological evidence pointed to the rarity of endogenous auto-infection—all recent work has supported this view. After stating that there must be "some form of external infection which escaped recognition" he drew attention to the possibility of parturient women conveying the organisms on their fingers to the vulva or vagina. This is a danger well recognized by the supporters of

the theory of droplet infection, and special precautions are laid down to thwart it: precautionary advice; a mask for the woman known to have an infected throat; careful and repeated cleansing of their hands; and, in my own practice, a double clove-hitch on the wrists to prevent the hands of the woman in twilight sleep from wandering to the vulva.

As the experts at this congress were oblivious to the droplet danger it is not surprising that the current textbooks on midwifery contained no reference to it. And yet it would seem that, thinking logically, there is the same necessity for rigid aseptic technique in obstetric as in surgical practice. In the seventh edition (1912) of Hirst's *Obstetrics* the mask is considered necessary in major but not in minor surgery, and not in making obstetrical examinations and manipulations. This fallacious view has been held to a ridiculous extent. I have recently seen a gynaecologist wear a mask in an operating theatre whilst repairing a perineal tear of thirty years' duration, but disdain its use when suturing, in a labour room, a tear sustained ten minutes previously. Thus most of us acted less than ten years ago.

The English textbooks on midwifery were late in drawing attention to the danger. One of the best-known did not refer to it in 1925 in its sixth edition. In the seventh edition of 1931, however, we read that the human throat is the chief habitat of the haemolytic streptococcus, and that masks completely covering mouth and nose should be worn by all who are in attendance on labour and by nurses during the puerperium.

It will be asked: Is there evidence of benefit from the rigid use of these, together with other rational precautions, such as early detection and exclusion with appropriate treatment of attendants who have infected air passages and the immediate investigation and segregation of lying-in women at the onset of pyrexia? It is obvious that the masks must be efficient and that they should be in position before the hands are sterilized and before instruments and other appliances are removed from the sterilizer and laid out ready for use—preferably, indeed, before the labour room is entered.

I believe there is convincing evidence from several maternity hospitals where for the last five years or more there has been thorough bacteriological control of the work of the hospital—both indoor and outdoor. Comparison of the results in these two departments has yielded unexpected figures of great significance.

Dr. Joan Rose of the Elsie Inglis Hospital, Edinburgh, in a second report (1936) on "Bacteriological Control," says: "Observations on the incidence of haemolytic streptococci in lying-in women have been continued over a period of six years. The figures for the past three years show that while the general morbidity in hospital and on districts remains low, the pyrexial rate associated with these organisms is *higher on the district than in the hospital.*"

Dr. R. G. Douglas (1937) states that all these precautions—and he lays great stress on efficient masking—have been rigidly employed at the New York Lying-in Hospital since September, 1932. He shows that the incidence of streptococcal pyrexia was two and a half times as frequent in the home as compared with the hospital deliveries. The same result has been obtained in comparable conditions in the practice of the Jessop Hospital, Sheffield, under the control of two whole-time bacteriologists.

The Report of the Obstetric Registrar of University College Hospital, London, for 1936 records that whilst

two cases of haemolytic streptococcal infection occurred in 348 district deliveries there were no cases among the 1,034 deliveries in the hospital itself.

Dr. Leonard Colebrook reports that during the last five years the risk of developing a haemolytic streptococcal infection has been 30 to 40 per cent. higher for any booked case delivered in her own home than it is for similar booked cases delivered in Queen Charlotte's Hospital, and this in spite of the hospital having to deal with many already infected emergency cases. He continues: "I am sure that whereas the risk of sepsis in well-conducted maternity hospitals is growing less and less, we shall never have adequate control over the manifold dangers of familial infection in the overcrowded houses of the poor. I am glad, therefore," he adds, "to see the tendency for more hospital deliveries, and I think we should encourage and facilitate that movement."

Air-borne Infection in Dust

These results have led Colebrook and others to revive investigations into the possible danger of air-borne infection in dust. That the atmosphere was the chief vehicle of contagion was believed by many a hundred years and more ago. The belief was substantiated when Pasteur showed that the air was populated with microbes which caused putrefaction and fermentation. John Tyndall, the physicist, devised beautiful experiments and apparatus to demonstrate the presence of germ-laden dust in the atmosphere, and thus upset the theory of spontaneous generation. Lister attempted to counter the danger by the use of the carbolic spray, within the range of which surgical operations and even childbirth were conducted. Further bacteriological investigations drew attention away from this to other more frequent sources of infection. But it is our duty to leave no possible source of danger unheeded.

The most recent work on air-borne infection has been carried out by William and Mildred Wells (1936) of Harvard University. The experiments are ingenious and the results impressive. In an air-conditioned room with an air centrifuge respiring at the human rate "sneeze-powder" was projected at will among a group of graduates. Bacterial samples of the air were collected by the centrifuge into blood-agar tubes. These workers demonstrate that "it would seem obvious that under conditions of crowding in enclosed rooms we are breathing one another's nasopharyngeal flora, as we once drank each other's intestinal flora in our water supplies." In searching for means to effect air sterilization they have found that germs are killed by ultra-violet rays. Floodlights emitting these rays are now in use in a corridor of the Children's Hospital, Cambridge, Massachusetts, and in the number of the *Journal of Thoracic Surgery* for October, 1936, there is a picture of an operation being conducted within the range of a battery of these lamps.

Charles White, the founder of St. Mary's Maternity Hospital, keenly alive to the dangers of "the foul and disagreeable air" of many hospital wards, strongly advocated ventilators and "every other assistance for clearing the wards of foul air." He would no doubt be delighted with the modern American air-conditioned hospital ward.

Conclusion

I fully realize that I should be doing a great disservice to a cause which I have much at heart if I left the impression that it is only against streptococcal infections, and in particular against the droplet danger, that I advocate precautionary measures. It is largely a matter

of time that has led me to confine myself to this one danger.

The history of the discovery of infections by other organisms—staphylococci, the gonococcus, pneumococci, the *Bacillus coli*, the bacillus of Welch, etc.—and the special precautions required to anticipate and thwart each one of them, are of great interest and importance. It would be folly to neglect them while concentrating on one special danger. The most complete surgical technique is essential in really safe midwifery practice. New knowledge may lead to its modification, and it may be that a future Lloyd Roberts lecturer will find this paper of mine useful in composing his own on “The Rise and Fall of the Obstetrical Face Mask.”

BIBLIOGRAPHY

- Berger, Paul (1899). *Bull. Mém. Soc. Chirurgie Paris*, **25**, 189.
 Chaucer, Geoffrey (1389). *Canterbury Tales*—“The Manciple’s Prologue.”
 Churchill, Fleetwood (1849). *Essays on Puerperal Fever* (Syd. Soc.), p. 35, London.
 Clarke, John (1793). *Essay on Febrile Diseases of Lying-in Women*, London.
 Colebrook, Dora C. (1935). Medical Research Council Special Report Series, No. 205.
 Colebrook, Leonard (1936). *Prevention of Puerperal Sepsis*, Sherratt and Hughes, Manchester.
 Collins, Robert (1835). *Practical Treatise on Midwifery*, London.
 Congress, British (1925). *J. Obstet. Gynaec. Brit. Emp.*, **32**, 239.
 Douglas, R. G. (1937). *Amer. J. Surg.*, **35**, 352.
 Eden, T. W., and Holland, W. E. (1925, 1931). *Manual of Midwifery*.
 Flügge, O. (1895). *Z. Hyg. Infektr.*, **25**, 179.
 Gordon, Alexander (1795). *Epidemic Puerperal Fever of Aberdeen*, London.
 Hamilton, Alexander (1781). *Outlines of Midwifery*, p. 263, Edinburgh.
 Hart, D. (1936). *J. thorac. Surg.*, **6**, 45.
 Harvey, William (1651). *De Generatione*. Trans. by Willis (Syd. Soc.), London.
 Henry, William (1831). *Philosophical Magazine*, **10**, 363.
 Holmes, Oliver Wendell (1843). *Essay on the Contagiousness of Puerperal Fever*, Boston.
 Hübener, W. (1898). *Z. Hyg. Infektr.*, **28**, 348.
 Kanter, A. E., and Pilot, I. (1924). *Surg. Gynec. Obstet.*, **38**, 96.
 Lea, A. W. W. (1910). *Puerperal Infections*, London.
 Meigs, Charles D. (1856). *Treatise on Obstetrics*, 3rd Ed., p. 635, Philadelphia.
 Meleney, F. L., et al. (1928). *Amer. J. Obstet. Gynec.*, **16**, 180.
 Mikulicz, Johann (1897). *Cib. Chir.*, **24**, 713.
 Nixon, Joan, and Wright, H. D. (1929). *Lancet*, **1**, 1242.
 Pasteur, Louis (1877–9). *The Life of Louis Pasteur*, by René Vallery-Radot, p. 291, Paris.
 Portsmouth Municipal Maternity Hospital Outbreak of Pyrexia (1924). *British Medical Journal*, **2**, 623.
 Robertson, John (1832). *London med. Gaz.*, **9**, 503.
 Rose, Joan K. (1937). *J. Obstet. Gynaec. Brit. Emp.*, **44**, 278.
 Rutter, Dr. (1882). W. S. Playfair: *Treatise on the Science and Practice of Midwifery*, **2**, 342.
 Simpson, James Young (1851). *Edinb. monthly J. med. Sci.*, **13**, 72.
 Skoda (Vienna) (1850). *Amer. J. med. Sci.*, **20**, 529 (Abstract).
 Tyndall, John (1902). *Fragments of Science*, 6th Ed., London.
 Watson, B. P. (1928). *Amer. J. Obstet. Gynec.*, **16**, 157.
 Wells, Wm. F. and Mildred W. (1936). *J. Amer. med. Ass.*, **107**, 1698, 1805.
 White, Charles (1773). *Treatise on the Management of Lying-in Women*, London.

A report by the Food Council to the President of the Board of Trade on its inquiry into the costs and profits of retail milk distribution in Great Britain has now been published by H.M. Stationery Office, price 9d. The main objects of the inquiry were to examine the extent and the causes of the differences between the financial results, per gallon of milk sold, of various businesses; to ascertain whether retail milk distributors are, on the whole, making an unduly high rate of net profit or rendering unnecessarily expensive services; and to consider the possibility of eliminating any such services and achieving generally a more economical retail distribution of milk. In its conclusions the Council suggests possible lines of action by which a reduction might be made in the average margin covering the expenses and profit of the distributor, in order to achieve a reduction in the retail price of milk.

THE LYMPHOID TISSUE OF THE ALIMENTARY CANAL*

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(WITH SPECIAL PLATE)

The lymphoid tissue of the alimentary canal consists of the tonsillar and pharyngeal ring, the Peyer’s patches, the vermiform appendix, and the solitary follicles of the large intestine, but in order to come to a proper understanding of these lymphoid foci a few words about the lymphatic system as a whole are necessary.

It is the accepted belief now that in vertebrates the lymphatics form a closed tube system and do not communicate with the tissue spaces, with the serous cavities such as the peritoneal and pleural cavities, or with the ventricles of the brain or the central canal of the spinal cord. The lymphatic capillaries form dense networks in most of the tissues of the body, these unite to form larger vessels, and the largest, the right and left thoracic ducts, empty their contents into veins and contribute various-sized lymphocytes to the blood stream. Moreover, as Drinker and Field (1933) point out, care must be taken to distinguish between true lymph obtained from lymph vessels; tissue fluid, the fluid in the region outside blood and lymph capillaries in the cellular interspaces; and plasma, the unclotted fluid of the blood, which differs markedly from lymph and tissue fluid in protein content and to a less degree in salt content. As Drinker and Field say, “the three fluids should not be confused with one another or with blood serum as is frequently done—particularly by immunologists uninoculated with a physiological conscience.”

Moreover, as Maximow (1935) asserts:

“The lymphatic networks are distinguished from the blood capillaries by ending blindly in rounded or swollen ends. This is best seen in the mucous membrane of the small intestines, where a network of lymphatic capillaries or a single blindly ending vessel, the central lacteal, extends in the lamina propria up to the end of the villus. The lymphatic capillaries form expanded networks of considerable size round the solitary and aggregated lymphatic follicles of the intestine. They consist of a single layer of flat endothelial cells. The larger lymphatic vessels have valves and slightly thickened walls containing elastic fibres, smooth muscle, and interlacing collagenous fibres.”

Maximow concludes his description of lymphatic capillaries and vessels with the important statement, “As the lymphatics form a closed endothelium-lined system of tubes the tissue juice must pass through the endothelial cytoplasm to reach the lumen of the lymphatics.”

But the lymphatic system does not consist only of lymphatic vessels. These have associated with them collections of lymphoid tissue known as lymph nodes—sometimes called lymphatic glands—and also lymphoid follicles, the latter being solitary or aggregated follicles according to whether they are single or gathered into groups.

I do not propose to refer further to the lymph nodes, although their internal structure is very similar to the collections of lymphoid tissue elsewhere, but I wish to

* A lecture given at the Henry Lester Institute of Medical Research, Shanghai.