

Listerism, its Decline and its Persistence: the Introduction of aseptic surgical Techniques in three British Teaching Hospitals, 1890–99

T H PENNINGTON*

The view that Joseph Lister's introduction of antiseptics was a revolutionary act is an old one. Thus John Tyndall wrote in 1881 "Living germs . . . as Schwann was the first to prove, are the causes of putrefaction. Lister extended the generalization of Schwann from dead matter to living matter, and by this apparently simple step revolutionized the art of surgery. He changed it, in fact, from an art into a science."¹ Watson Cheyne, Lister's assistant in Edinburgh and King's College Hospital, London, continued the theme in his exhaustive monograph on antiseptic surgery.² His book not only apotheosizes Listerism as practised at the beginning of the 1880s, but marks its apogee, as antiseptics underwent no fundamental change—in principle—thereafter, despite major technical developments such as the abandonment of the spray and the substitution of mercurial antiseptics for carbolic acid. Indeed, from the middle of the decade a rapidly increasing proportion of the innovations in wound treatment and operative techniques aimed at the prevention of infection were deliberately characterized by their describers not as antiseptic, but as aseptic.

What was the nature of this shift from antiseptics to asepsis?³ Was it a seamless, evolutionary development, as epitomized by Schimmelbusch in the preface of his book on asepsis—"the present work is nothing more than an extension of that beneficent idea

*Professor T H Pennington, Department of Medical Microbiology, University of Aberdeen, Medical School, Foresterhill, Aberdeen AB9 2ZD.

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¹ J Tyndall, *Essays on the floating-matter of the air*, London, Longmans, Green, 1881, p. viii.

² W W Cheyne, *Antiseptic surgery: its principles, practice, history and results*, London, Smith, Elder, 1882, p. 598.

³ This paper uses the term "antiseptic" to categorize methods that use chemicals to kill or prevent the growth of bacteria, and "aseptic" for methods that use heat transmitted *via* water, steam or air, or physical methods, for the first of these

purposes. In the 1880s Cheyne used "aseptic" in a completely different sense, to categorize *Listerian* antiseptics. Thus in 1882 he stated that "there are many methods by which the occurrence of putrefaction is more or less interfered with, but they all act on a more or less imperfect principle, with the exception of that introduced by Mr Lister, which founded on a true principle, attains the ideal of results—viz. a complete absence of putrefaction—an asepsis. His method, then, is best designated by the term expressing its result—Aseptic" (Cheyne, *op. cit.*, note 2 above). In 1889 he again uses "aseptic" in this way—to categorize the precautions "taken with the view of preventing the entrance of micro-organisms into the wound," the "principle . . . introduced by Sir Joseph Lister", reserving "antiseptic" for the methods in which "micro-organisms are admitted and then means are taken to prevent or interfere with their growth and fermentative action" (W W Cheyne, 'Antiseptic surgery', in C Heath (ed.), *Dictionary of practical surgery*, London, Smith, Elder, 1889, p. 71).

... the antiseptic treatment of wounds”,⁴—or was it “an entirely novel process, based on a completely different theory?”⁵ Perhaps the answer lies between these two. Thus Neuber of Kiel in introducing a paper describing his aseptic technique commented that he was particularly interested in “der Vereinfachung des Lister’schen Verfahrens”—simplifications of Lister’s procedures—but emphatically distanced himself from the procedures by referring later to his personal role in “dem Kampf gegen die antiseptische Behandlung”—the fight against the antiseptic treatment.⁶

This paper attempts to define the nature, and chronology, of the antiseptic-aseptic shift with particular reference to developments in Britain. It will propose that the two most important driving forces behind it were developments in bacteriology, and responses to the toxicity of antiseptics for patients and for members of the surgical team. Detailed consideration will be given to the temporal sequence of events in three British teaching hospitals—St Thomas’s and St Bartholomew’s in London, and the Royal Infirmary in Aberdeen.

Carbolic Acid and Mercuric Chloride in antiseptic Surgical Practice

Two long papers published in the *Lancet* in 1867 and in 1875 mark the beginning and end of Joseph Lister’s original contributions to the development of the antiseptic method.⁷ Between these dates its underlying principle remained constant—“the exclusion of all microbes from wounds”—and its central technical feature, the use of carbolic acid as an antibacterial agent, remained in essence unchanged. Direct attempts to test this property of carbolic acid were not made at this time, and a belief in its bactericidal efficacy extended to those conducting bacteriological experiments, the spray being used to prevent contamination from the air when inoculating cultures.⁸

The first work to cast doubt on the bactericidal power of carbolic acid as used in antiseptic regimes was published by Ranke in 1874.⁹ He examined wound discharges microscopically, and found organisms in fourteen out of fifteen cases following an aseptic course after antiseptic treatment. On this basis he rejected the germ theory as a sufficient explanation of the aetiology of septic diseases. This work, and that of other microscopists active in the 1870s, was critically reviewed by Watson Cheyne.¹⁰ He pointed out the technical difficulty faced by these workers in identifying microorganisms, and in particular the problem of distinguishing micrococci from granular matter. He then went on to describe a long series of studies conducted by himself on the cultivation of microorganisms from wounds treated in different ways. He

⁴ C Schimmelbusch, *The aseptic treatment of wounds*, London, H K Lewis, 1894, p. xv.

⁵ N J Fox, ‘Scientific theory, choice and social structure: the case of Joseph Lister’s antiseptics, humoral theory and aseptis’, *Hist. Sci.*, 1988, 26: 367–97.

⁶ G Neuber, ‘Zur Technik der aseptischen Wundbehandlung’, *Centralblatt für Chirurgie*, 1892, 19: 393–401.

⁷ J Lister, ‘On a new method of treating compound fractures, abscess, etc. with observations on the condition of supuration’, *Lancet*, 1867, i:

326–39, 357–9, 387–9, 507–9; ii, 95–6; *idem*, ‘On recent improvements in the details of antiseptic surgery’, *Lancet*, 1875, i: 365–7, 401–2, 434–6, 468–70, 603–5, 717–19, 787–9.

⁸ J Chiene and J Cossar Ewart, ‘Do bacteria or their germs exist in the organs of healthy living animals?’, *J. Anat. Physiol.*, 1878, 12: 448–53.

⁹ H R Ranke, ‘Die Bakterien-vegetation unter dem Lister’schen Verbands’, *Centralblatt für Chirurgie*, 1874, 1: 193–4.

¹⁰ Cheyne, *op. cit.*, note 2 above, pp. 245–7.

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concluded that while *bacteria*—rod-shaped organisms—could only be cultured from wounds *not* treated aseptically, *micrococci* could often be found without difficulty in wounds correctly managed antiseptically, and which were therefore expected to have no organisms. At this time Cheyne was sceptical about the surgical significance of these organisms. He commented, “Dr. Ogston has recently assigned much more serious consequences to them, but the subject is at present too debatable to be suitable for discussion here.” Alexander Ogston had published papers in 1880 and 1881 which claimed that micrococci caused acute abscesses. In 1881 Ogston’s view was that

Lister’s spray and dressing are sufficient, when used with great care, to prevent the entrance of any living organisms into a wound. In certain regions of the body, such as the axilla, a proportion of the operations, however carefully performed, have in my experience, become septic from the development of micrococci, which had, I presume, existed in the large sweat and sebaceous glands, where they had been sheltered from the action of the carbolic acid. Once micrococci have gained access to a wound, it is not easy to eradicate them. Ordinary Lister’s dressings will not do so.

In papers published in 1882 which argued against the views held by Lister and Cheyne on suppuration and the aetiology of abscesses—that the former could be “antiseptic” and that the latter could be caused by chills—he drew attention to German work which cast doubt on the antiseptic efficacy of the spray:

again, the observations of Mikulicz have shown that in such experiments the protecting influence of the spray is by no means great, a fact that I can personally corroborate, as a careful series of experiments hitherto unpublished concerning the protective influence of the spray carried out in the Aberdeen Infirmary by Messrs Davidson and Prain, yielded results somewhat similar to those by Mikulicz.

Similar conclusions were drawn by John Duncan in 1883 from his bacteriological studies on antiseptically-treated wounds and on the efficacy of the spray. Using liquid cultures he found organisms in 40 per cent of clinically aseptic wounds that had been treated antiseptically. In detailed experiments with Tyndallized Darby’s meat fluid he did not succeed in preventing airborne infection with the spray and concluded that the results “seem to me definitely to prove that, so far as the distribution of floating germs in the air is concerned, the spray is perfectly ineffectual”.¹¹

¹¹ A O Ogston, ‘Über Abscesse’, *Archiv für Klinische Chirurgie*, 1880, 25: 588–600, ‘Report upon micro-organisms in surgical diseases’, *Br. med. J.*, 1881, i: 369–75. John Duncan, ‘Germs and the spray’, *Edinburgh med. J.*, 1883, 28: 778–86. A O Ogston, ‘Micrococcus poisoning’, *J. Anat. Physiol.*, 1882, 16: 526–67, 17: 24–58. W W Cheyne, ‘Report upon micrococci in relation to wounds, abscesses and septic processes’, *Br. med. J.* 1884, ii: 553–6, 599–605, 645–7. J Mikulicz, ‘Zur Sprayfrage’, *Archiv für Klinische Chirurgie*, 1880, 25: 707–51. See also L G Wilson, ‘The early recognition of streptococci as a cause of disease’, *Med. Hist.*, 1987, 31: 403–14. No other publications from Aberdeen on the efficacy of the spray have been traced. It is probable that the work was done in 1881 or early 1882, and that Davidson and Prain were medical students. At this

time surgery classes were taken in the third, penultimate, year of study, (C I Pennington, *The modernization of medical teaching at Aberdeen in the nineteenth century, quincennial studies in the history of the University of Aberdeen*, Aberdeen University Press, 1994) so it is probable that they graduated in either 1882 or 1883. The only graduates for these years with these names (W Johnston, *Roll of the graduates of the University of Aberdeen 1860–1900*, Aberdeen University Press, 1906) were James McKenzie Davidson (1856–1919) MB CM 1882, Ophthalmic Surgeon, Aberdeen Royal Infirmary 1886–94, Head of X-ray department, Charing Cross Hospital, knighted 1912, and David Prain (1857–1944) MA 1878, MB CM 1883, Indian Medical Service 1884–1906, Director, Royal Botanic Gardens, Kew, 1905, FRS 1905, knighted 1912.

The first detailed quantitative and comparative studies to test the antibacterial properties of carbolic acid were done by Robert Koch in 1881. He used the solid media that he had devised to test the effect of many compounds, including carbolic acid, on pure cultures of *Micrococcus prodigiosus*, the bacteria of blue pus, anthrax bacilli, and anthrax spores. His conclusions were direct:

1 per cent [carbolic acid] and 2 per cent failed to destroy anthrax spores within a week; 3 per cent took seven days, 4 per cent three days, and even 5 per cent required more than one day. These results were most unexpected, since it is customary to regard a 2 per cent solution of carbolic acid in water as able to destroy all germs in a few seconds or minutes. The surgeon washes his hands, and cleanses his instruments in such a solution, and believes that he has thereby rendered them free from living organisms, and that they may then with safety be brought into contact with open wounds. We now see, however, that beyond the mere mechanical effect of washing, such precautions are of no avail whatever in the case of organisms as resistant as anthrax spores.

Bearing in mind that carbolic oil is absolutely inert, and that a spray of 2 per cent, or even 5 per cent, carbolic solution can have no appreciable effect upon spores in the brief time occupied by a surgical operation, and further, that in order to prevent bacterial growth the carbolic acid must be present in the proportion of 1 to 400, it cannot any longer be a matter for surprise that, in spite of the most scrupulous antiseptic precautions, bacteria are so often found under Listerian dressings.

In addition to showing the poor performance of carbolic acid, Koch demonstrated that of more than seventy compounds tested, mercuric chloride (corrosive sublimate) was the only disinfectant "which, without any previous moistening or other preparation of the articles to be disinfected, destroys the most resistant organisms in a few minutes by a single application of a highly dilute solution".¹²

Koch's conclusions had a major impact on antiseptic practice. Corrosive sublimate was rapidly introduced as an antiseptic in many centres.¹³ Lister summarized Koch's work with approval in an 1884 address which described his own experiments on the development of corrosive sublimate dressings. He pointed out that corrosive sublimate had already been extensively used in Germany, chiefly in the form of sublimate wood-wool, and went on to describe its anti-putrefactive properties and its application in practice—much of his work being concerned with the mitigation of one of its major disadvantages, its highly irritative property. Lister's perception of the superiority of sublimate and other mercurial disinfectants over carbolic persisted for the rest of his active career, being demonstrated by his continued use of the compounds and by his publications on the subject.¹⁴ Its use for irrigating wounds and disinfecting hands became widespread, and subject to bacteriological study.¹⁵

¹² R Koch, 'Ueber Desinfektion', *Mittheilungen aus dem kaiserlichen Gesundheitsamte*, 1881, 1: 234—and abstracted in English '1—Disinfection', in W W Cheyne (ed.), *Recent essays by various authors on bacteria in relation to disease*, London, New Sydenham Society, 1886, pp. 499, 504 and 517.

¹³ At von Bruns' clinic in Tübingen, from November 1882 sublimate replaced carbolic in dressings and irrigation fluid, in the preparation of catgut, silk, sponges and drains, and for the disinfection of hands. G Walcher, 'Ueber die Verwendung des "Holzstoffes" zum antiseptischen Verbands, insbesondere den Sublimat-

Holzwoleverband', *Mittheilungen aus der Chirurgischen Klinik zu Tübingen*, 1883–84, 1: 168–212.

¹⁴ J Lister, 'An address on corrosive sublimate as a surgical dressing', *Br. med. J.* 1884, ii: 803–7; *idem*, 'Note on the double cyanide of mercury and zinc as an antiseptic dressing', *Br. med. J.*, 1907, i: 795–6.

¹⁵ H Kümmel, 'Wie soll der Arzt seine Hände desinficiren?' *Centralblatt für Chirurgie*, 1886, 13: 289–95; E von Bergmann, 'Die antiseptische Wundbehandlung in der Kgl. chirurgischen Universitäts-Klinik zu Berlin', *Klinisches Jahrbuch*, 1889, 1: 147–66.

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However, the properties of corrosive sublimate which distinguished it from carbolic acid also served to prevent its substitution for the latter substance in other component parts of the antiseptic system. Thus its lack of volatility and extreme toxicity precluded its use in the spray, and its chemical reactivity with metals meant that it could not be used for the treatment of instruments. It shared with carbolic the potential to poison patients.¹⁶

The Development of Heat and Steam Sterilization Techniques in Germany

Koch's early work on disinfection at the Gesundheitsamt was not restricted to the testing of antiseptics. Two papers with Wolfhügel, and with Gaffy and Loeffler investigated disinfection by heat and by steam. As with disinfectants, he came to an unequivocal conclusion.

The results leave no room for doubt as to the form of disinfection by heat which should be adopted in the future. The hot air apparatus is complicated and costly, and is untrustworthy when the objects to be disinfected are at all bulky, or folded, or wet. Disinfection by steam under pressure at temperatures above 100°C is open to the same objections, though to a less degree. In every respect exposure to a current of steam at 100°C is a far more satisfactory method than either of the above. It is more certain, more simple, more rapid, more economical both in original cost and expense of working and involves less injury to the articles to be disinfected.¹⁷

Surgeons responded slowly to these findings and recommendations. For technical reasons it was much more difficult to put them into effect than to replace one disinfectant with another. Boilers that delivered steam and left treated dressings dry had to be designed, constructed and tested, and methods and procedures to prevent the rusting of instruments and the dulling of cutting edges had to be found. For committed antisepticians another set of arguments also had to be faced. Lister's own words summarize these well.

The operation being concluded, an external dressing such as shall effectually prevent the access of septic mischief till healing is accomplished is, of course, a matter of essential importance. For this purpose some surgeons have of late years employed materials merely aseptic, such as cotton wadding sterilized by heat. But such a dressing having nothing in it to counteract any accidental defilement, must demand an almost impossible degree of care in its manipulation in order to ensure that it is truly aseptic as left upon the patient. The mere aseptic dressing has also the fatal defect that it is liable to be occasionally soaked to the surface with discharge, in which septic development will then be free to spread inwards to the wound. I believe, therefore, that a dressing, in order to be trustworthy, must be charged with some chemical antiseptic substance.¹⁸

¹⁶ Cheyne, op. cit., note 2 above, pp. 588–92, discusses carbolic acid poisoning at length. For corrosive sublimate poisoning see H Kümmel, 'Über Sublimatintoxication der Laparotomien', *Centralblatt für Chirurgie*, 1886, 13: 377–82, and Annotations, 'Perchloride of mercury as an antiseptic', *Lancet*, 1886, ii: 638–9; This comments on its 'Dangers being unpleasantly illustrated.'

¹⁷ R Koch, G Wolfhügel, 'Untersuchungen über die Desinfektion mit heisser Luft', *Mittheilungen aus dem kaiserlichen gesundheitsamte*, 1881, 1: 301; R Koch, G Gaffy and F Loeffler, 'Versuche über die

verwerthbarkeit heisser Wasserdämpfe zu Desinfektionszwecken', *ibid.*, 1881, 1: 322, and abstracted in English, 'III. Disinfection by hot air', 'III. Disinfection by steam', in W W Cheyne (ed.), *Recent essays by various authors on bacteria in relation to disease*, London, New Sydenham Society, 1886, quote, p. 533.

¹⁸ J Lister, 'On the principles of antiseptic surgery', *Virchow-Festschrift*, 1891, vol. 3; reprinted in *The collected papers of Joseph, Baron Lister*, 2 vols, Oxford, Clarendon Press, 1909, vol. 2, pp. 340–8.

Investigations on heat and steam sterilization along the lines indicated by Koch were, nevertheless, conducted in a number of centres. Those done in Ernst von Bergmann's University Clinic in Berlin—the Ziegelstrasse Klinik—were particularly influential in Britain because Schimmelbusch's book describing practice there was translated into English and published in London within two years of its appearance in Germany in 1892.¹⁹ Two papers from the Ziegelstrasse Klinik describe the development of aseptic practice by its members from 1886 onwards.²⁰ Schimmelbusch started his 1891 account by stating that the work of Koch and his school on disinfection was year on year making itself more felt. He presented bacteriological evidence which showed the superiority of steam sterilization over hot air and sublimate treatment, and discussed the problems encountered by those using carbolic acid for instrument treatment, especially the maceration of the skin of the hands, carboloria, and other unpleasant interferences with general health. Von Bergmann's 1889 paper describes the treatment of dressings, towels and surgeons' "leinenen, langen, weissen, Röcke, eigentlich Talare" (long linen white coats, actually gowns) in a Henneberg and Rietschel's "Desinfektor" in steam at 100°C for half an hour, the steam sterilization of silk in a small steam apparatus and of the sterilization of syringes by the laboratory of the University Institute of Hygiene. Metal instruments were disinfected in 3 per cent carbolic acid for a quarter of an hour before use.

Schimmelbusch indicated that at about this time the clinic began to steam sterilize dressings in a Lautenschläger apparatus, a sterilizer small enough (25 cm internal diameter and 50 cm high) to be accommodated in the operating theatre²¹ (Figure 1). Schimmelbusch described this in detail, and reviewed previous attempts to sterilize metal instruments by heat. He rejected hot air, autoclaving and hot oil treatment for a variety of reasons, mostly to do with their practicality. His paper then described at length a method for instrument sterilization based on the work of Davidsohn, in which they were boiled for five minutes in alkaline water. This was sufficient for disinfection and did not cause rusting.²² Alkaline conditions were achieved by using a 1 per cent soda (sodium carbonate) solution. The dulling of cutting edges was prevented by stopping the movement of instruments in the boiler; instruments rested on a wire gauze holder. Schimmelbusch concluded his account with a detailed description of bacteriological studies on the scrubbing brushes used to clean surgeons' hands, patients' skin and metal instruments; he concluded that "it is quite enough to keep them always in 1 in 2000 solution of sublimate, by this means even those in constant use are kept free from germs".²³

The aseptic techniques used in von Bergmann's clinic were publicized at the Tenth International Medical Congress in Berlin in 1890.²⁴ Bergmann described this in his preface to Schimmelbusch's book:

¹⁹ Schimmelbusch, op. cit., note 4 above. This book went through two German editions in 1892 and 1893 entitled *Anleitung zur aseptischen Wundbehandlung*, Berlin, A Hirschwald.

²⁰ Von Bergmann, op. cit., note 15 above; C Schimmelbusch, 'Die Durchführung der Asepsis in der Klinik des Herrn Geheimrath von Bergmann in Berlin', *Archiv. für Klinische Chirurgie*, 1891, 42: 123–71, quote, p. 146.

²¹ H Settegast, 'Ein Sterilisator für chirurgische

Zwecke', *Centralblatt für Chirurgie*, 1890, 17: 105–7.

²² H Davidsohn, 'Wie soll der Arzt seine Instrumente desinficiren?', *Berliner Klinische Wochenschrift*, 1888, 25: 697–703.

²³ Schimmelbusch, op. cit., note 4 above, p. 60.

²⁴ The Tenth International Medical Congress was addressed by both Lister and Koch, the latter announcing his tuberculin treatment of tuberculosis. Lister made his famous apology for the spray at the

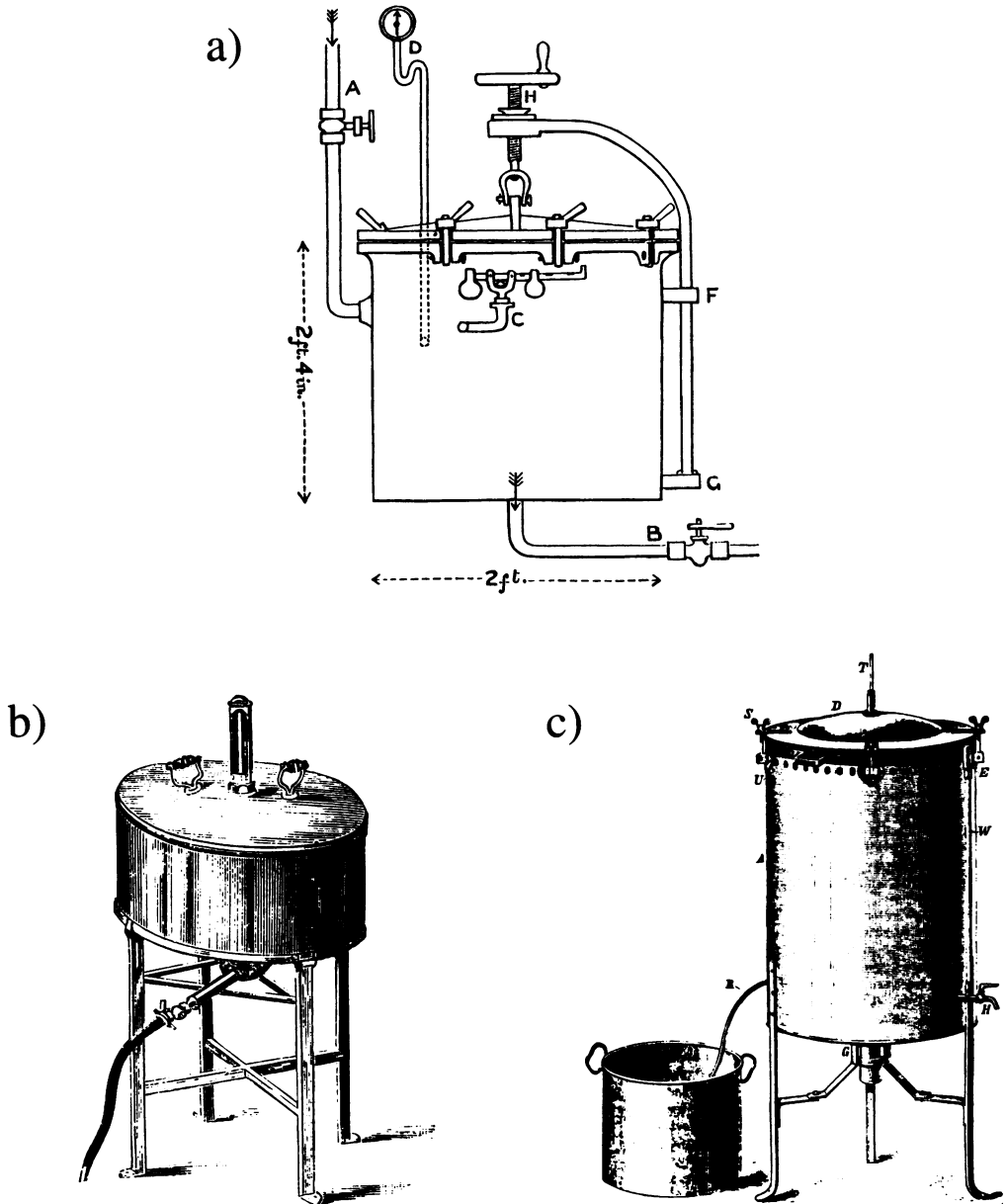


Figure 1: Sterilizers for dressings and other bulky items:

(a) Autoclave installed at St Thomas's Hospital in 1894 (from White, note 58).

(b) Hot air sterilizer used in the Martha ward operating theatre, St Bartholomew's Hospital, 1893 (from Cripps, note 71).

(c) Lautenschläger steam sterilizer of the pattern used at Aberdeen Royal Infirmary (from Schimmelbusch, note 20).

during the Tenth International Medical Congress, the undersigned exhibited in the Clinic the appliances for the sterilization of dressings, and entrusted his assistant surgeon, Dr. C. Schimmelbusch with the demonstration of their efficacy against the micro-organisms which affect the course of healing and the treatment of wounds. The blue colour, produced in the growth of the bacilli of blue pus, proved to the spectator the effects of the methods demonstrated, even without a microscope. We were then asked, upon all sides, to collect together and describe what we had shown. This book is meant as an attempt to satisfy that wish.²⁵

Direct evidence that this demonstration was not without effect—though perhaps not the one desired by von Bergmann—can be found in the account of the Surgery section of the Congress given by the *Lancet*'s reporter:

The material submitted to this section was perhaps on the whole more remarkable for quantity than for quality . . . no great or startling innovation in surgery has marked this International Congress . . . It is evidence that the aseptic, as opposed to antiseptic, method of operating, has obtained a firm foothold in Germany. The greatest care is taken, in Professor Bergmann's clinic, to sterilize everything that comes into contact with the wound; the instruments are all boiled for 5 minutes in a 1% solution of carbonate of soda in a special kettle which stands in the operating theatre. The results are excellent, but the mass of dressings used for each case seems clumsy and wasteful.²⁶

The German literature provides direct evidence that, despite the *Lancet*'s criticism, the firm foothold of aseptic practice—in particular the use of steam sterilized dressings—became a focus for expansion in the period immediately after the Congress. Thus technical papers describing sterilizers for dressings using steam at atmospheric pressure appeared in considerable numbers between 1889 and 1892 with the majority being published in 1891 and 1892.²⁷

The developments in Germany exemplified by the work in von Bergmann's clinic provide evidence which supports the view that the new aseptic techniques could be characterized as developments of antisepsis arising in response to its deficiencies, rather

Congress: "I feel ashamed that I should have ever recommended it for the purpose of destroying the microbes of the air". In this address he cannot quite bring himself to accept that "the floating particles of the air may be disregarded in our surgical work". Thus, since the abandonment of the spray "three years ago, we have been careful to compensate for its absence, not only by antiseptic washing and irrigation, but by surrounding the seat of operation with widespread towels wrung out of an antiseptic solution. For the spray, although useless for the object for which it was originally designed, had its value as a diffuse and perpetual irrigator, maintaining purity of the surgeon's hands and their vicinity as an unconscious caretaker". Lister compares carbolic acid unfavourably with corrosive sublimate—"our wounds no longer being subjected to the constant irrigation of the spray, and carbolic acid having given place to the less irritating, though more efficient, solutions of corrosive sublimate, serous discharge is much less than formerly, and less drainage is required". For the text of Lister's address see *Br. med. J.*, 1890, ii: 377–9.

²⁵ Schimmelbusch, op. cit., note 4 above, p. xiii.

²⁶ 'The International Congress in Berlin, Surgery', *Lancet*, 1890, ii: 359.

²⁷ Schimmelbusch, op. cit., note 4 above, p. 222, lists many papers describing steam sterilizers; also see M Straub, 'Ein Sterilisator zu chirurgischen Zwecken', *Centralblatt für Chirurgie*, 1889, 16: 569–72, which describes the invention of a Dutch military surgeon. The practical nature of these papers is illustrated by the common use of woodcuts, their titles—'Ein praktischer Sterilisationsapparat . . .' (Kronacher), 'Ein transportabler Dampf—und Wassersterilisator' (Ivar Sternberg), 'Ein billiger [cheap] und einfacher [simple] Dampfsterilisator' (H Merke), 'Ein tragbarer [portable] Wasserdampf Sterilisator für Verbandmaterial' (Kaschkaroff)—and their references to manufacturers and prices. In 1890 Settegast's sterilizer (made by Lautenschläger, Berlin), cost 90 marks. In 1892 Kronacher's apparatus (from O Reinig, Munich) cost 38 marks, without accessories, and Merke's cost 28 marks from J Fehrmann, Berlin. The largest Lautenschläger steam sterilizer (used in von Bergmann's clinic) was priced at £16 5s. with dressing boxes in the 1894 English edition of Schimmelbusch's book. An exchange rate of 20 marks to the pound is indicated by the translators' note on prices for sphagnum moss.

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than as methods arising *de novo*. Similar sentiments about antiseptics were being promulgated by advocates of asepsis in the United States. Thus in an address to the Obstetrical Society of Philadelphia on 6 May 1886 entitled ‘Asepsis not antiseptics. A plea for principles, not paraphernalia, in laparotomy’, the gynaecologist Howard Kelly vigorously attacked the disadvantages of antiseptics:

Medicine, like other branches of science, has been most retarded in its growth by the accumulation of all sorts of useless details. Some of these manifestations still clog the advance of abdominal surgery, and will be given up with a notable diminution in the general percentage of morbidity. I refer to the use of carbolic acid and mercuric solutions at the operating table, and to the continued use of any elaborate abdominal dressings. The use of antiseptics in the patient’s belly is full of danger and inconsistency.

Kelly went on to emphasize their toxicity, “if used in strength sufficient to certainly prevent sepsis, the patient is very often killed along with the germs”, and their ability to engender a false sense of security, the “great tendency of all operators, and in particular their assistants, to forget the principle involved, and pin their faith to the accidental means of establishing it”.²⁸

What was the relationship between the old and the new methods in Britain? Antiseptics had become widely established there by the early 1880s. The writer has shown that osteotomy—an operation that he has used as an indicator of antiseptic practice—had become well established as a routine procedure during this time, and that it was done with regularity at many hospitals, including St Bartholomew’s and St Thomas’s.²⁹

Antiseptic and aseptic surgical Techniques in Aberdeen

For Aberdeen, Alexander Ogston’s autobiographical note on the introduction of antiseptic surgery describes the events in terms similar to that of a religious conversion. Ogston made visits, without introduction, to Lister—who had just taken up the Clinical Surgery Chair in Edinburgh—and to Hector Cameron’s wards at Glasgow Royal Infirmary.

He took me to his wards in the Infirmary. FIVE MINUTES [Ogston’s capitals] later found me convinced of the truth of the marvellous discovery. I was shown a knee-joint which had been opened, and, after instruction, was allowed to handle and examine it. There could be no room for doubt. The wound made into the joint was there, but where was the inflammation that ought fatally to have followed? There was none . . . I was shown other cases, but that first one was sufficient. I saw that a miraculous change had come over our Science, and my mind was almost bewildered with the glorious vision of all that it entailed. I felt inclined to sit down, cover my face with my hands, and think out what the great revelation implied in the future.³⁰

Ogston’s enthusiasm for Lister’s methods is epitomized by the refrain in the verse describing him in the 1886–90 medical students’ graduation souvenir brochure.³¹

²⁸ H A Kelly, ‘Asepsis not antiseptics. A plea for principles, not paraphernalia, in laparotomy’, *Transactions of the Obstetrical Society of Philadelphia*, in *Am. J. Obstet. Dis. Women and Children*, 1886, **19**: 1076–81.

²⁹ T H Pennington, ‘Osteotomy as an indicator of antiseptic surgical practice’, *Med. Hist.*, 1994, **38**: 178–88.

³⁰ W H Ogston, H H Cowan, H E Smith, *Alexander Ogston, K.C.V.O.: memories and tributes of relatives, colleagues and students, with some autobiographical writings*, Aberdeen University Press, 1943, pp. 93–5.

³¹ J M Bulloch, T Holt, *Pilgrim’s progress in print and picture*, Aberdeen, privately printed, 1890.

The spray, the spray, the antiseptic spray,
A.O. would shower it morning, night, and day.
For every sort of scratch,
Where others would attach
A sticking-plaster patch,
He gave the spray.

Direct evidence that Ogston continued to use carbolic acid-based Listerian methods throughout the 1880s is contained in his manuscript lecture notes on operative surgery of 1883, and in a synopsis of lectures published by his assistant, J Scott Riddell, in 1889. The former lists among the requisites for operations a spray table, a spray producer or irrigator, two 80 oz bottles of 1:20 carbolic lotion, one piece of Lister's gauze, carbolic oil, and the need for five assistants—the chloroformist, one to hold basins and sponges, one operation assistant, one to hold the limb, etc., and one at the spray producer.³² Scott Riddell's synopsis lists as topics for consideration in detail in the lecture course classical Listerian items such as carbolic gauze, Lister's dressing, carboloria, carbolic sprays, and the management of the spray at operation.³³ Ogston's lecture notes provide no evidence to suggest that he used corrosive sublimate at this time, though it appears, with boric acid, salicylic acid, iodoform and turpentine in the list of antiseptics described in the synopsis. Holograph notes in the synopsis, probably made in the 1893–94 academic session state “corrosive sub. very strong disinfectant 1—100,000 prevent growth of germs . . . ac. carbol promotes oozing and HgCl₂ does not. Ac. carbol irritate vasomotor nerves. Hg Cl₂ apt to produce ptyalism, stains all instruments. colour basins.”³⁴ Ogston's manuscript notes provide further evidence of the changes in his surgical practice through the 1890s. As the majority of operations in the hospital were done by him, at least at the early part of this period,³⁵ his technique can be considered to be representative of that of the hospital as a whole. The second volume of his notes on operative surgery carries no date but was probably written in either 1889 or 1890.³⁶ The spray is still listed, with 1:20

³² A Ogston, manuscript, 'Operative Surgery' No. 1, Aberdeen University Library, MSU/1095/2/1. The first lecture is dated 7 May 1883.

³³ J Scott Riddell, *Synopsis and note-book of lectures on practical surgery for the use of students attending the practical surgery class*, Aberdeen, James C M'Kay, 1889. This work follows the format of the traditional Scottish printed lecture synopsis, giving very brief outlines of topics to be covered in the classes. A blank page for student notes faces each printed page. An example of its format is given by the section on sepsis: “1. Sepsis is synonymous with Putrefaction. 2. Putrefaction is due to Fermentation. 3. Fermentation is caused by particles floating in the air. 4. Fermentation is probably due to micro-organisms (Bacilli or Micrococci) which are always present in fermenting liquors (Germ Theory)”. The copy in Aberdeen University Library was owned by A G Milne (MB, CM, 1895) and has many of his holograph notes.

³⁴ T H Pennington, 'The Lister steam spray in Aberdeen', *Scott. med. J.*, 1988, 33: 217–18.

³⁵ The Annual Report of the Royal Infirmary for

1888 lists the operations conducted by its three surgeons, A Ogston, O Will and R J Garden. They did 352, 54, and 130 respectively. Ogston's list contains most of the “capital” operations, including 8 ovariectomies (Will 0, Garden 2), removal of breast (8, Will 0, Garden 2), hip and knee resections (11, Will 0, Garden 1) and amputations of arm or leg (8, Will 0, Garden 7). Ogston also did most of the tonsillectomies (10, Will 1, Garden 4), osteotomies (10, Will 0, Garden 1), sequestrotomies (8, Will and Garden 0) and évitement of tubercular foci from bones (19, Will 2, Garden 2).

³⁶ A Ogston, manuscript, 'Operative Surgery' No. 2, Aberdeen University Library, MS/U/1095/2/2. Ogston updated his notes by gumming in slips of paper with short quotes from journals. These are dated and referenced; the earliest one in this volume refers to “Küster, C f Ch, '90, 539”. (This paper was published in the *Centralblatt für Chirurgie* on 19 July 1890 and was entitled, 'Über die Grundsätze der Behandlung von Eiterungen in starrwandigen Höhlen mit besonderer Berücksichtigung des Empyems der Pleura'.)

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carbolic lotion and Lister's gauze. Additions to the requirements listed in 1883 include salicylic wool 2 oz, and an operation coat. Ogston prepared another set of notes on operative surgery, probably in 1896.³⁷ The old carpet, the old sheet, Lister's gauze, salicylic wool, carbolic oil, the spray producer, the spray table, and the assistant at the spray producer are no longer listed, and "mercuric soloids" are given as an alternative to 1:20 carbolic lotion. Additions are antiseptic wool 2 oz, disinfectant ointment, and loose gauze.

The Annual Reports of the Infirmary list expenditures on carbolic acid and antiseptic wools and dressings from 1888 to 1895, and it is possible to estimate the expenditure on carbolic acid from the Infirmary 'Details of expenditure' book for succeeding years.³⁸ Significant sums were spent on carbolic acid throughout the period 1888–1898 (Figure 2); it is likely that the decline in expenditure per operation that occurred after 1892 was due to the combined effect of a shift to mercurial disinfectants, the introduction of boiling for instrument sterilization and the abandonment of the spray. The 1893–98

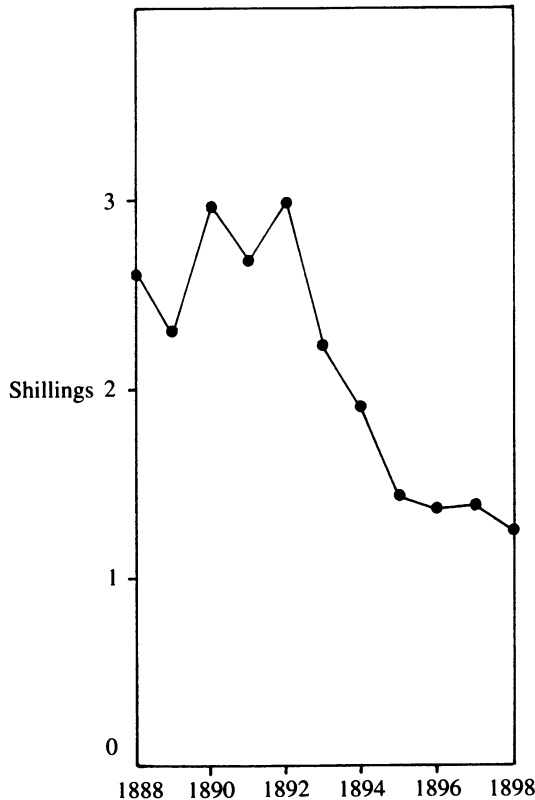


Figure 2: Expenditure on carbolic acid per operation, Aberdeen Royal Infirmary, 1888–1898.

Data from the Annual Reports of Aberdeen Royal Infirmary (1888–95) and the Infirmary 'Details of expenditure' book (1896–98, see note 38). The number of operations was calculated as the annual number of cutting operations on inpatients (reductions, breaking down of adhesion, forced rectifications, chloroform examinations, electrolysis, forced dilation of strictures, setting of fractures were excluded) plus the number of similar operations on outpatients for 1890 (the only year for which full statistics were reported) plus the annual number of surgical outpatient attendances for 1891–98 divided by 3.8 (in 1890 this fraction of surgical outpatients had cutting operations).

³⁷ A Ogston, manuscript, 'Surgery notes', No. 7, Aberdeen University Library, MS/U/1095/3/4. Page 1 bears the pencil note "1st Friday 1896–97".

³⁸ Aberdeen Royal Infirmary, 'Details of expenditure', Grampian Health Board Archives, GRHB1/2/54. This lists expenditure on carbolic acid

for the years 1893 to 1896; for 1897 and 1898 expenditure on this item is not given separately. F C Calvert & Co was the main supplier, and expenditure for the latter years has been determined by identifying purchases from this company.

'Details of expenditure' book also lists regular purchases being made from the "Sanitary Wood Wool Company" throughout the period. This firm sold "Hartmann's Patent Wood Wool Preparations", some of which were intended for use with sublimate gauze.³⁹

It is therefore possible that a shift from carbolic to sublimate-based dressings had occurred by this time. There is no evidence that surgeons in Aberdeen emulated von Bergmann by making use of the disinfectant that the Infirmary obtained in 1890.⁴⁰ The first unequivocal indication of the introduction of aseptic practice was the decision on 21 November 1892 by the Medicines and Instruments Committee to purchase a Schimmelbusch's apparatus for sterilizing instruments at a cost of £4.15s.0d.⁴¹ It is not recorded whether this purchase was linked to the construction of the new surgical block of the hospital which was taking place at this time. Designed in 1889, this included two operating theatres, one large and semicircular and the other small and rectangular, about 20 feet wide with tiered standings for 60 spectators.⁴² Ogston submitted a letter of resignation to the Infirmary Board of Directors on 12 April 1892, and as part of the ensuing dialogue (he withdrew his letter in September 1892) he requested "that in the new buildings the smaller operating theatre shall be reserved for my ovariectomies, abdominal sections, and antiseptic operations". This arrangement was agreed to later in the year.⁴³ In March 1897 the 'Details of expenditure' book records a purchase from F and M Lautenschläger costing £16.17s.6d. It is very likely that the item purchased was the "Dampfsterilisator von Lautenschläger grössten Formates" recommended by Schimmelbusch for dressings, gauze, gowns and towels in his book.⁴⁴ It cost £16.5s.0d. in 1894. An undated photograph shows the apparatus installed by the door of the large 1892 operating theatre.⁴⁵

Ogston's lecture notes reflect the introduction of the Schimmelbusch and Lautenschläger apparatus in Aberdeen. Thus in notes dated 1895–96 he refers to the temperature of boiling soda as being "150° Cent".⁴⁶ In the notes of 1896–98 his list of "Requisites at Operations" is crossed out and "Keen's Operation Blanks" is written in pencil on the facing page.⁴⁷ One of these blanks is included in the notes. Clearly intended for use in private practice, the surgeon is instructed to check its list of items, tear off the page, and "send to the chemist". Reflecting mixed antiseptic-aseptic practice, it lists sterilized gauze, mops and towels, and operation coats and gloves (all in a sterilizer kettle) and various antiseptic dressings (salicylic, sublimate, and cyanide). Ogston's

³⁹ Trade Directory, *Medical annual*, Bristol, 1892. An advertisement in this volume (p. 749) describes the products in full, listing wood wool (made of pure pine) wadding, tissue, sheets, antiseptic diapers, antiseptic gonorrhoea bags and vaccination pads. Also see Hartmann Lehrnbecker, 'Beitrag zur Kenntnis der Eigenschaften der Sublimatverbandstoffe', *Deutsche militärärztl. Zeitschrift*, 1890, Hft 2 68, abstracted in *Centralblatt für Chirurgie*, 1891, 18: 254–5.

⁴⁰ Minutes of the Building Committee, 20 August 1890, *Aberdeen Royal Infirmary Minute Book from 11 March 1890*, Grampian Health Board Archives, GRHB1/1/20. Quotes were obtained for a Washington Lyon disinfectant at £195, with £28 extra for mahogany lagging, and one from Manlove Elliot and Co. at £189 10s. 0d., with £18 extra for lagging. The latter was accepted—without the lagging.

⁴¹ Minutes of the Medicine and Instruments

Committee, 21 November 1892, *Aberdeen Royal Infirmary Minute Book from 11 March 1890*, Grampian Health Board Archives, GRHB1/1/20.

⁴² I D Levack, H A F Dudley, *Aberdeen Royal Infirmary*, London, Baillière Tindall, 1992.

⁴³ Minutes of Meetings of the Board of Directors (various dates, pp. 336, 354, 367, 383), *Aberdeen Royal Infirmary Minute Book from 11 March 1890*, Grampian Health Board Archives, GRHB1/1/20.

⁴⁴ Schimmelbusch, op. cit., note 4 above.

⁴⁵ Levack, Dudley, op. cit., note 42 above, plate 33, p. 95.

⁴⁶ Ogston, manuscript, 'Surgery notes', No 1, Aberdeen University Library, MSU/095/3/1, p. 9. Schimmelbusch's instrument sterilizer used a soda solution. Its boiling point was elevated only a few degrees by the soda.

⁴⁷ Ogston, op. cit., note 37 above.

alteration to his notes is not dated—he went on using them until his retirement in 1909—but a clear indication of aseptic practice in Aberdeen at the end of the century is given in a paper by Henry Gray, based on an address to the Medical Society of the University in 1899.⁴⁸ After qualifying in 1895 Gray had spent a year (1896–97) in Germany studying with von Bergmann, König and Jansen in Berlin, Schede in Bonn and Trendelenburg in Leipzig, among others.⁴⁹ His obituary describes him as leaving Aberdeen when it was “gradually shedding some of the trappings of the antiseptic system and striving after a safe but simple technique. He found German surgery far advanced in the development of the aseptic system, and when he returned to Aberdeen he had mastered this technique and brought much new equipment with him.”⁵⁰ Gray summarized his practice in 1899 as follows:

to carry out the method . . . requires an initial expenditure of about £12 to £16. This money is spent on a sterilizer and kettles as originally manufactured by Lautenschläger in Berlin. A local chemist may keep a sterilizer (as for example Messrs Davidson and Kay in Aberdeen). I can carry in a kettle of this size, 12½"x9", sufficient equipment for practically any operation. When carefully packed it holds six towels, two operation sheets, a mackintosh, two or three coats, mops, dressings and bandages . . . For sterilization of instruments many cheap boilers are made, but an ordinary fish-kettle does quite well.

Antiseptic and aseptic surgical Techniques at St Thomas's Hospital

At St Thomas's Hospital antiseptic methods were being used as early as 1871, when Sydney Jones excised a knee joint under carbolic spray and dressed the wound with carbolic gauze.⁵¹ In his review of the radical cure of hernia, H B Robinson considered that his compilation of cases, which covered the years 1879–1890, started “from the period when aseptic surgery was established on a sound basis”.⁵² Henry Clutton's review of eighteen cases of strangulated hernia covered two years—either 1876 to 1878 or 1877 to 1879 (his report appeared in the ‘Hospital Reports’ for 1878, but it is probable that this volume was not published until the following year). Ten cases were treated with carbolic oil, and eight antiseptically, confirming that the establishment of widespread antiseptic practice in the hospital occurred at about this time.⁵³ Direct evidence that antiseptic methods continued to be used throughout the 1880s is contained in a paper by G H Makins and F C Abbott published in 1892. This reviewed the treatment of compound fractures in the hospital between 1881 and 1890. At the earliest part of the decade all cases were disinfected with 5 per cent carbolic lotion and dressed with carbolic gauze in “early Listerian fashion”. Further dressings, as the first, were done under the carbolic spray. The spray then “gradually fell into desuetude”, and for the last four years was

⁴⁸ H M W Gray, ‘The conduct of operations in private practice, with special reference to preparation and after treatment’, *Scott. med. surg. J.*, 1899, 5: 289–301. H M W Gray MB, CM 1895, House Surgeon to A Ogston 1896, Assistant Surgeon, Aberdeen Royal Infirmary 1898, Surgeon 1904.

⁴⁹ Application and testimonials of H M W Gray for the Regius Chair of Surgery, Aberdeen University Library MSU 912.

⁵⁰ “T.F.” (T Fraser), ‘H M W Gray’, obituary, *Br. med. J.*, 1938, ii: 814–15.

⁵¹ S Jones, ‘Contribution towards the surgical treatment of diseased joints’, *St. Thomas's Hospital Reports*, 1873, vol. 3, pp. 255–90.

⁵² H B Robinson, ‘Sixty-four cases of non-strangulated hernia treated by radical cure’, *St. Thomas's Hospital Reports*, 1889, vol. 19, pp. 33–56.

⁵³ H H Clutton, ‘Remarks on a few cases of strangulated hernia’, *St. Thomas's Hospital Reports*, 1878, vol. 9, pp. 9–20.

employed little or entirely dispensed with. Iodoform was used with carbolic in the mid-period and for its last five years 1/1000 mercuric perchloride was used, with bicyanide of mercury gauze at the end of the period.⁵⁴ During the summer and autumn of 1883 a eucalyptus spray was used, and eucalyptus gauze dressings were used in 1883 and 1884. The change to mercuric perchloride was accompanied by the introduction of pine-wood bag dressings.⁵⁵ Evidence that the carbolic spray continued in use until at least 1886 is contained in a paper by William MacCormac published late that year on the operative repair of ruptures of the urinary bladder. In one case “the operation lasted two hours and was conducted under the carbolic spray throughout, save for a few minutes when the steam failed”.⁵⁶

At St Thomas’s the first indication of a change to aseptic methods was the introduction of filtration for the sterilization of water in 1890.⁵⁷ A Berkefeld filter was used to produce water in the operating theatres for irrigating wounds and flushing the peritoneum, and for the production of saline. In 1891 the operating theatres (one male and one female) were refurbished. The medical school prospectus for 1892 describes them as having lately been “thoroughly refitted, refloored and provided with electric lighting. They are now peculiarly well adapted for the carrying out of aseptic surgery”. By 1894 an autoclave had been installed to sterilize dressings (Figure 1). Using steam from the boiler of the pharmaceutical laboratory, it was operated at 18 to 20 lbs/sq inch (125°). Dressings were packed into lidded 8" x 4" cylindrical glass jars by the sister in charge of the case to be dressed; the apparatus was under the control of the pharmacist.⁵⁸ Problems were encountered with this autoclave in that dressings were left wet after exposure to steam, and “within a year or two of its construction” it “was found to be too small for the demands made upon its working capacity”.⁵⁹ The first defect was “to a large extent remedied” by adding a steam ejector. Another autoclave was installed to remedy the second. It had a horizontally arranged cylindrical chamber 3ft 9in by 2ft 9in, a steam jacket and a sterilizing cycle that started and finished with a vacuum being drawn by ejector. Tinned copper cylindrical canisters (4" x 4" and 8" x 6") were used for plugs, sponges, pads and dressings, and boxes of the same material (10" x 8" x 6" and 14" x 12" x 10") held towels, bandages, aprons and overalls. Edmund White, the pharmacist, wrote in his 1901 paper that since 1894 “the use of sterilised dressings has been gradually extended until, at the present time, antiseptic dressings have been almost entirely displaced”.⁶⁰

Henry Clutton, a senior surgeon at this time, was an enthusiast for asepsis.⁶¹ In a report on the operative treatment of fractures of the patella he related that in operations

⁵⁴ G H Makins, F C Abbott. ‘The results of treatment of 322 compound fractures of the long bones in this hospital between the years 1881 and 1890 inclusive’, *St. Thomas’s Hospital Reports*, 1892, vol. 20, pp. 183–203.

⁵⁵ G H Makins, ‘The result of excision of a portion of rib in fifteen cases of empyema’, *St. Thomas’s Hospital Reports*, 1884, vol. 14, pp. 145–78.

⁵⁶ W MacCormac, ‘Some observations on rupture of the urinary bladder’, *Lancet*, 1886, ii: 1118–22.

⁵⁷ C S Wallace, ‘The surgical technique in St. Thomas’s Hospital, 1899’, *St. Thomas’s Hospital Reports*, 1899, vol. 27, pp. 315–29.

⁵⁸ E White, ‘Sterilised surgical dressings and sterilised water’, *St. Thomas’s Hospital Reports*, 1894, vol. 22, pp. 53–6.

⁵⁹ E White, ‘Aseptic dressings: an account of their production and organised distribution in St. Thomas’s Hospital’, *St. Thomas’s Hospital Reports*, 1901, vol. 28, pp. 405–14.

⁶⁰ *Ibid.*

⁶¹ Henry Hugh Clutton 1850–1909, Assistant Surgeon, St Thomas’s Hospital 1878, Surgeon 1891–1909. He described himself as a “strong advocate . . . for the true Listerian method of dressing” (H H Clutton, ‘Remarks on a few cases of

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performed between April 1894 and July 1896 antiseptics were not used except for pre-operative skin preparation with perchloride of mercury.⁶² Instruments were boiled, and wool sponges, towels, cloths and dressings were sterilized. The joints were not routinely washed out or irrigated, and he commented that “it is a curious and suggestive fact that the only joint which was irrigated and drained suppurred”. Cuthbert Wallace’s report of 1899 indicates that practice was mostly aseptic by that time.

Surgeon, house surgeon, anaesthetist, dressers, theatre sister, theatre nurse, ward sister and probationer wash their hands and forearms, and then put on sterilised blouses that fasten behind, completely cover up the clothes and leave the forearms bare to just above the elbow.

Instruments, hand-basins, porringers, receivers, and the instrument tray were sterilized in the theatre, the first in a “sterilizer” by boiling for five minutes, and the latter in “the big boiler”. Water was filtered. Cotton gloves were used generally—being sterilized by autoclaving—with rubber gloves being used for septic cases “to prevent the hands of the operator carrying infection”. The rubber gloves were sterilized with the instruments. Two Washington Lyon sterilizers had been installed for treating bulky items. These had steam ejectors for pulling a vacuum at the beginning and end of the sterilization cycle, which used high pressure superheated steam. Components of antiseptic practice persisted:

solutions of perchloride of mercury (1 in 500), carbolic (1 in 20) are kept in the theatre, but their use is not nearly so frequent as formerly. Flushing of clean wounds is getting rarer and rarer, and even when done the agents employed are nearly always sterilised water or saline. In fact, the use of chemicals to wounds is almost a thing of the past.

Cyanide gauze dressings and, occasionally, iodoform gauze were still used, although “sublimate, sal. alembroth, and salicylic wool have practically disappeared”.

In his account of the cleansing of hands, Wallace emphasizes the unsatisfactory nature of antiseptic practice in this regard. Thus

smoothness of the skin is greatly helped by the avoidance of chemical lotions, which are apt to precipitate the blood on the hands and nails, and also to cause chaps and cracks. Another point is that the time that can be practically afforded for the application of chemicals is far short of the time sufficient for the germicidal action of the chemical. In consequence of this, it is impressed on students and nurses that a perfunctory dip in a chemical is of no value, and in order to clean the hands they must be washed with soap and water.

Despite the sharpness of his attack against chemicals, they retained a place in hand cleansing, the actual cycle in 1899 being soaping and washing in running water→drying with sterile towel→perchloride wash (or sterilized water)→sterilized water wash→cotton gloves.⁶³

Wallace’s account and White’s 1901 paper indicate that sterilization was done under bacteriological control. A clinical laboratory was opened at the hospital in November 1897. In its first year of operation 51 examinations were made of filtered water from the

strangulated hernia’, *St. Thomas’s Hospital Reports*, 1878, vol. 9, pp. 9–20. His obituarist G H Makins (*Br. med. J.*, 1909, ii: 1504–6) describes him as follows: “commencing as an ardent disciple of the antiseptic faith, he became a strong and early supporter of aseptic methods”.

⁶² H H Clutton, ‘Treatment of fractures of the patella (both early and late) by operation’, *St. Thomas’s Hospital Reports*, 1895, vol. 24, pp. 121–32.

⁶³ Wallace, op. cit., note 57 above.

operating theatres and 40 tests were done on sponges, towels, wool, catgut, and kangaroo tendon. Similar numbers of tests were done by the laboratory in each of the next four years.⁶⁴

Antiseptic and aseptic Techniques at St Bartholomew's Hospital

Antiseptic methods were introduced to St Bartholomew's Hospital by Thomas Smith. He visited Lister in the summer of 1875 and arranged for his house surgeon to receive instruction in Edinburgh later that year. In 1876 he was using the antiseptic method in

those cases which, under ordinary treatment, are specially liable to local manifestations of inflammation, and are generally the sources of well-marked constitutional disturbances. I have not used the plan in ordinary amputations, tumours, operations for hernia, nor in the treatment of acute superficial abscesses, for in these the results of surgery in a healthy hospital is usually satisfactory, but in resections of large joints, in wounds of joints and compound fractures, in deep abscesses, and especially in chronic abscesses connected with joint disease or caries of bone.⁶⁵

Despite Smith's activities, St Bartholomew's gained the reputation as an institution hostile to Listerism. This was refuted by William Walsham:

It has been said, evidently by persons totally unaccustomed to the methods of the Hospital, that antiseptic surgery is not practised at St. Bartholomew's. Speaking for myself, I can only say that ever since I have been an officer of the Hospital I have employed antiseptic methods according to the lights of the period, and I believe that my former Chief, Sir Thomas Smith, was the first to practise them in London.⁶⁶

Nevertheless, during the 1880s two of the five full surgeons of the hospital were antipathetic towards antiseptic methods. Sir William Savory's attitude had been publicly expressed in 1879 through his hostile address 'On the prevention of blood poisoning in the practice of surgery',⁶⁷ and Marrant Baker was described by his colleague and obituarist Alfred Willett as a surgeon who "never took cordially to antiseptic surgery; he had been very much involved with Callender's view of strict cleanliness, and he believed rather in deodorizer rather than in antiseptics, and quite failed to grasp asepticism".⁶⁸ Willett was himself using antiseptic methods at the beginning of the 1880s.⁶⁹

Aseptic methods at St Bartholomew's were introduced by Harrison Cripps and Charles B. Lockwood. Cripps was appointed as an assistant surgeon in 1882; he was not considered to be a particularly enthusiastic antiseptician.⁷⁰ From 1892 his hospital work

⁶⁴ From 22 November 1897 to 31 December 1898 the laboratory examined 1664 specimens. Major categories of investigation were tests for typhoid fever (Widal-Grünbaum test, 175 specimens), diphtheria (266 specimens) and tests on sputum and urine (many for tubercle bacilli) (141 specimens). Similar numbers and types of test were done for the next two years. L L Jenner, 'Report on the clinical laboratory for 1898', *St. Thomas's Hospital Reports*, 1899, vol. 27, pp. 305–9; 'Report for 1899', *ibid.*, 1901, vol. 28, pp. 315–17; C G Seligmann, 'Report for 1900', *ibid.*, 1902, vol. 29, pp. 313–14.

⁶⁵ T Smith, 'Clinical lectures on Lister's treatment of wounds and abscesses by the antiseptic method', *Lancet*, 1876, i: 453–55.

⁶⁶ W J Walsham, G Smith, S P Huggins, 'Report of operation cases from Mr. Walsham's wards', *St.*

Bartholomew's Hospital Reports, 1898, vol. 34, 263–302.

⁶⁷ W Savory, 'On the prevention of blood poisoning in the practice of surgery', *Br. med. J.*, 1879, ii: 210–17.

⁶⁸ A Willett, 'In memoriam. Marrant Baker', *St. Bartholomew's Hospital Reports*, 1896, vol. 32, pp. xii–xlix.

⁶⁹ E Colville, 'Cases from Mr. Willett's wards', *St. Bartholomew's Hospital Reports*, 1883, vol. 19, pp. 203–10.

⁷⁰ H W W, 'In memoriam. William Harrison Cripps', *St. Bartholomew's Hospital Reports*, 1924, vol. 57, pp. 1–4. In this D'Arcy Power is quoted, "I do not remember that he had at any time an especial regard for Listerian methods, at any rate he did not operate under the carbolic spray which was then in vogue."

focused on abdominal surgery in women. The lengthy description of his work published in 1893 indicates that his practice had substantial aseptic components at that time. An operating theatre was reserved for his cases. It had three sterilizers—a barrel shaped boiler for sterilizing water, a copper instrument boiler shaped like a fish-kettle, and a hot air sterilizer for dressings (Figure 1). The theatre was provided with glass tables for instruments and dressings and a glass cabinet for the storage of instruments. The operating table was made of brass and glass, and incorporated a copper hot-water reservoir so that the patient could be kept warm during the operation. The patient's skin was prepared pre-operatively with an overnight dressing of lint soaked in 1 in 20 carbolic, and on the morning of the operation the walls of the theatre, and bowls, trays and basins were cleaned and washed with 1 in 1000 perchloride of mercury. Sponges and pads were boiled and kept in 1 in 20 carbolic ready for use.⁷¹ In 1896 the operating theatre was rebuilt at Cripp's expense with marble floor and alabaster walls, and in 1897 biniodide of mercury was introduced as an antiseptic. At this time Cripps changed into a suit of flannels just fresh from the wash immediately before operating. Ten minutes were "spent at the washing basin with soap, hot water and the nail brush. The hands were soaped for two minutes in 1:500 spirit solution of biniodide, then rinsed in a watery solution of the same".⁷²

Lockwood was appointed to an assistant surgeons'hip at St Bartholomew's in 1892. He was also surgeon to the Great Northern Hospital, where from 1888, with the assistance of the Scientific Grants Committee of the British Medical Association, he had conducted bacteriological studies on wound infections.⁷³ He gave classes on bacteriology to medical students at St Bartholomew's from 1890 to 1892. It is very likely that his practice had aseptic components at the time of his appointment, his 1893 paper on the radical cure of hernia indicating that instruments and silk were boiled for not less than fifteen minutes and that the operation field was surrounded by towels sterilized by steaming, being subsequently soaked in 1/40 carbolic.⁷⁴ It is probable, though direct evidence is lacking, that he was responsible for the installation of a steam sterilizer for dressings and sponges, and a boiler for instruments in the operating theatre at St Bartholomew's in April 1893.⁷⁵ Lockwood's obituarist indicates his enthusiasm for asepsis—"he had extreme views on asepsis, and sometimes could not control his feelings from conviction of the truth of his case".⁷⁶ Another expression of his enthusiasm was his book *Aseptic surgery*, published in 1896.⁷⁷ It was based on notes written for the *St. Bartholomew's Hospital Journal*. Forty-five of the 216 pages of text were taken up with an account of sterilization and disinfection by chemicals. As the length of this section

⁷¹ H Cripps, 'Abdominal section for ovariotomy etc. in the women's ward of St. Bartholomew's Hospital', *St. Bartholomew's Hospital Reports*, 1893, vol. 29, pp. 1–43.

⁷² H Cripps, 'A table of the cases of abdominal section in Martha ward during the year 1898', *St. Bartholomew's Hospital Reports*, 1899, vol. 35, pp. 23–36.

⁷³ C B Lockwood, 'Preliminary report on aseptic and septic surgical cases, including traumatic tetanus, gangrene and acute epiphysitis', *Br. med. J.*, 1890, ii: 943–7; *idem*, 'Further report on aseptic and septic surgical cases, with special reference to infection from the skin', *ibid.*, 1892, i: 1127–37; *idem*, 'Report

on aseptic and septic surgical cases, with special reference to the disinfection of skin, sponges and towels', *ibid.*, 1894, i: 175–81.

⁷⁴ C B Lockwood, 'The radical cure of femoral and inguinal hernia', *Lancet*, 1893, ii: 1297–1302.

⁷⁵ H T Butlin, 'A year's surgery at St. Bartholomew's Hospital', *St. Bartholomew's Hospital Reports*, 1893, vol. 29, pp. 89–101.

⁷⁶ 'In memoriam, C B Lockwood', *St. Bartholomew's Hospital Reports*, 1914, vol. 50, pp. 101–13.

⁷⁷ C B Lockwood, *Aseptic surgery*, Edinburgh and London, Young J. Pentland, 1896.

indicates, Lockwood's methods in the mid-1890s were not completely aseptic. Antiseptic dressings were used—"the dressing which I use nearly always consists of a) dusting with . . . iodoform . . . ; b) a layer of 5% carbolic gauze which has been soaked in biniodide lotion; c) a layer of alembroth wool; and d) an outside dressing and bandages." This practice, together with statements in the chapter on heat disinfection, suggest that he did not have a particularly effective steam sterilizer for bulky objects at his disposal; he used "one made of copper and arranged like an ordinary potato steamer" for towels, but had failures initially because he omitted to unfold them before loading the sterilizer.

The experience of his colleague Henry Butlin may also have influenced him. Butlin was appointed full surgeon in June 1892 and immediately "determined to try, on a larger scale than I had previously attempted, how far it is possible to dispense with the strictest aseptic and antiseptic methods of treating wounds". Instruments were treated in 1 in 20 carbolic for at least two hours, the patient's skin was treated with carbolic, and the hands of the operators were scrubbed with soap and water. "The dressings were at first [June 1892] boracic lint and plain cotton wool; later plain lint, cotton-wool and bandages. After the month of April, the dressings and sponges were sterilized, for we than had a large sterilizer in the operating theatre." Butlin was disappointed by his results, as 29 of his 61 cases suppurated. He concluded that

in spite of the low rate of mortality . . . this method cannot be employed in a large general hospital with the same confidence as strict antiseptic methods . . . The frequency of suppuration in the cases of amputation of the breast . . . led me to fear that some of the wounds had been poisoned with cotton wool. This opinion was strengthened by the fact that after the installation of our sterilizing apparatus . . . the suppurating cases very largely diminished; for from that time the cotton-wool used for sponges was carefully sterilized.⁷⁸

Butlin's account of his second year as full surgeon show that his experience had converted him to practice which was largely antiseptic. In most of its essentials heat sterilization was eschewed—except for instruments, which were boiled—and heavy reliance was placed on mercurials, particularly biniodide and alembroth.⁷⁹

Mixed antiseptic-aseptic practice continued at St Bartholomew's for the rest of the century. Walsham and Cripps independently describe how bacteriological control was carried out in 1898 by culturing portions of skin "snipped off" from the fingers of surgeons, house surgeons, assistant surgeons, dressers, nurses and the patient, and pieces of towels and sponges.⁸⁰ At the end of the century biniodide continued to be used for dressings and for the preparation of the hands of the surgical team—despite D'Arcy Power's comment at the time that "the method inflicts considerable damage upon the hands of the surgeon unless very great care is taken". Power also used biniodide for sponges—they were wrung out of hot 1:4000 solution—unlike Cripps, who boiled sponges and pads. In his 1903 review of ten years practice Cripps commented that "ten years ago flushing [of the peritoneal cavity] was frequently used . . . for the removal of the escaped contents of cysts and blood. It is hardly ever used for this purpose now".⁸¹

⁷⁸ Butlin, op. cit., note 75 above.

⁷⁹ H T Butlin, 'A second year's surgery at St Bartholomew's Hospital', *St. Bartholomew's Hospital Reports*, 1894, vol. 30, pp. 227–36.

⁸⁰ Walsham, op. cit., note 66 above; Cripps, op. cit., note 72 above.

⁸¹ D'A Power, 'The lessons of a year's surgical experience', *St. Bartholomew's Hospital Reports*, 1900, vol. 36, pp. 37–54. H Cripps, 'Ovariectomy and hysterectomy in Martha Ward', *St. Bartholomew's Hospital Reports*, 1903, vol. 39, pp. 143–66.

Laparotomies and the Introduction of aseptic surgical Practice

What impact did the shift from antiseptics to asepsis have on other aspects of surgical practice? Abdominal operations and their success or failure played an important part in debates about the merits and demerits of cleanliness, antiseptics and asepsis.⁸² The number of laparotomies done at the three hospitals each year from 1870 to 1902 (1904 for Aberdeen Royal Infirmary) is shown in Figure 3. A massive, rapid and sustained growth in the number of operations took place in all of them towards the end of the period. The year in which this type of increase started was different for each hospital, however, being 1891–92 for St Bartholomew's, 1894–95 for St Thomas's, and 1899–1900 for Aberdeen. None of the hospitals published statistical information about the operations done by individual surgeons for these years and so it is not possible to identify those done by surgeons known to use aseptic methods. Nevertheless, for St Bartholomew's 1891–92 was the year when Cripps started to do abdominal operations in his Martha Ward laparotomy theatre and it was the year of Lockwood's appointment. 1894–95 was the year when St Thomas's installed its first autoclave and Henry Clutton—already using full asepsis—began reporting his extensive series of appendicectomies.⁸³ In Aberdeen, Alexander Ogston retired as senior surgeon towards the end of 1898, thus freeing the small operating theatre that he had reserved in 1892 for his “ovariotomies and abdominal sections”;⁸⁴ Henry Gray was appointed assistant surgeon in the same year. That a shift to aseptic methods was not automatically followed by an immediate assault on the peritoneal cavity is demonstrated by German data—the number of laparotomies and ovariotomies done in von Bergmann's Ziegelstrasse Klinik rose from only 3 in 1888/89 to 16 in 1891/92.⁸⁵ Nevertheless, the close temporal link in the British hospitals between the appointment of keen asepticists and the installation of sterilizers, and the start of sustained growth in the number of laparotomies, suggests that aseptic methods played at the very least an important facilitatory role in the change. One way that growth rates of the sort demonstrated in Figure 3 could be sustained was by productivity increases. That there was slack in the system to allow these to occur without too much difficulty is demonstrated by changes that took place in the 1890s in the arrangements for operations at St Thomas's.⁸⁶ Thus in 1893 operations were done only on Wednesday and Saturday afternoons. A major change occurred in 1895 when lists were scheduled for every afternoon from Monday to Saturday, with late starts on Tuesday and Friday. These came into line with the other starting times in 1898.

⁸² Kelly (op. cit., note 28 above) supported his 1886 attack on antiseptics in abdominal surgery by reading letters from Thomas Keith and Lawson Tait. Also see G Rein, 'Zur Asepsis bei Laparotomien', *Centralblatt für Gynäkologie*, 1890, 14: 139–42; *idem*, 'Asepsik oder Antiseptik bei Laparotomien' Bericht über die Verhandlungen des X. Internationalen Kongresses zu Berlin, 4–9 August, 1890, *Centralblatt für Gynäkologie*, 14: 9–16.

⁸³ H H Clutton, 'Operative treatment of appendicitis', *St. Thomas's Hospital Reports*, 1898, vol. 26, pp. 25–51.

⁸⁴ Minutes, Board of Directors, ARI op. cit., note 36i.

⁸⁵ 'Statistik der stationären Kliniken und Polikliniken der Preussischen Universitäten, 1888/89–1891/92', *Klinisches Jahrbuch*, 1890, 2: 570–1; 1891, 3: 474–5; 1892, 4: 398–9; 1893, 5: 312–13.

⁸⁶ 'Days and hours for surgical operations', *St. Thomas's Hospital Medical School. Calendar and prospectus for 1893*, p. 21; for 1895, p. 21; for 1898, p. 21.

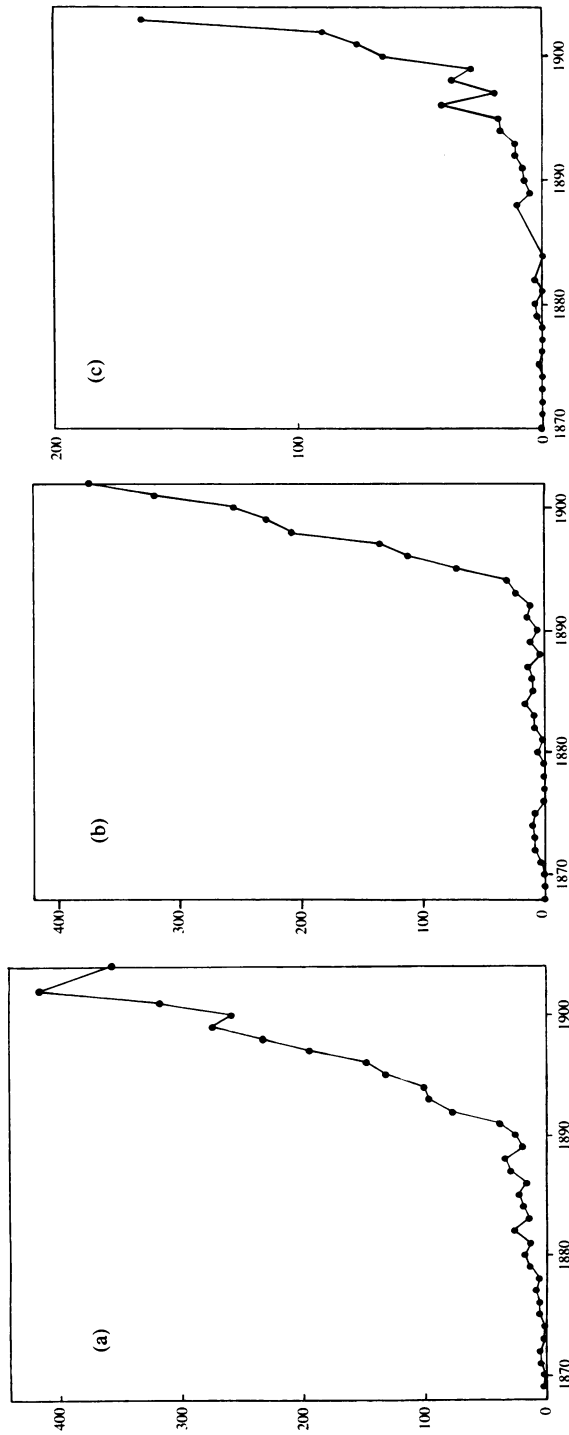


Figure 3: Number of laparotomies at: (a) St Bartholomew's Hospital, (b) St Thomas's Hospital, (c) Aberdeen Royal Infirmary. Data from St Bartholomew's Hospital Reports, St Thomas's Hospital Reports, and the Annual Reports of Aberdeen Royal Infirmary. The number of all abdominal operations (excluding coelotomies and hernia operations) is plotted.

Differences in early aseptic Practice in the three Hospitals

The analyses presented above show that early aseptic practice in the three hospitals differed in a number of ways. While all were boiling their instruments early in the decade, only St Thomas's and Aberdeen had reliable sterilizers for dressings and other bulky items working at its end. St Bartholomew's went on using complex antiseptic dressings into the twentieth century. Each hospital had adopted different initial approaches to the sterilization of bulky objects, Aberdeen using well-established German technology, which used steam at atmospheric pressure, St Thomas's the more complex and expensive autoclave and St Bartholomew's experimenting—probably unsuccessfully—with dry heat. It is not clear why St Thomas's adopted the approach it did. In one way its choice of Washington Lyon sterilizers can be seen as a reversion to past practice, because they were dual purpose machines and could be used as disinfectors like the Henneberg and Rietschel apparatus employed by von Bergmann in the late 1880s for the sterilization of bulky items.⁸⁷ On the other hand the choice of autoclaves rather than steamers was prescient as the former eventually came to occupy a monopoly for steam sterilization in hospitals. It is possible that the complexity of operation, the need for a piped steam supply, and the hazards associated with the operation of pressure vessels caused the St Thomas's autoclaves to be located in the pharmacy rather than in the operating theatres. Both Alexander Ogston and Henry Gray had spent much time in Germany and were very familiar with surgical practice there. It is therefore not surprising that Aberdeen should follow the Schimmelbusch system and make its major equipment purchase from a manufacturer in Berlin.

The influences at work at St Bartholomew's are harder to discern. Cripps, for example, gives no hint in his papers about the origin of his methods. His practice bears strong resemblances to that of Howard Kelly at the Johns Hopkins Hospital in Baltimore.⁸⁸ The description of Lockwood's surgical team as "the great aseptic firm", with its implication that other firms were not, underlines the absence of a central policy about sterilizers at St Bartholomew's, and the mixed antiseptic-aseptic nature of practice there.⁸⁹ The continued expenditure of significant—if declining—sums on carbolic acid and antiseptic wood wool at Aberdeen after the purchase of the Lautenschläger apparatus, and the use of steam-sterilized cyanide gauze at St Thomas's at the end of the 1890s indicates the persistence of mixed practice at these hospitals as well. The continued use of biniodide for hand preparation at St Bartholomew's at this time contrasts with the strong emphasis on soap and water at St Thomas's and Aberdeen ("the mechanical removal of the septic matter is the most important part to attend to"⁹⁰), and may reflect a greater emphasis on aseptic components in surgical practice in these centres.

The reason why Halsted introduced rubber gloves at the Johns Hopkins Hospital in 1890 is too well known to need repetition here.⁹¹ There is no evidence that gloves were

⁸⁷ W R Smith. 'Inquiry into the efficiency of the steam disinfectors in use in this country', *Journal of State Medicine*, 1896, 4: 301–12.

⁸⁸ For a photographic record of Kelly's operating rooms in 1889 and 1892, see A McG Harvey, G H Brieger, S L Abrams, J M Fishbein, V A McKusick, *A model of its kind*, Baltimore and London, Johns Hopkins University Press, 1989, vol. 2, pp. 73–5.

⁸⁹ 'In memoriam, C B Lockwood', op. cit., note 76 above.

⁹⁰ Gray, op. cit., note 48 above.

⁹¹ O H Wangenstein, S D Wangenstein, *The rise of surgery*, Folkestone, Dawson, 1978.

being worn at either St Bartholomew's or Aberdeen in the 1890s; Wallace's account indicates that in 1899 cotton gloves had just been introduced at St Thomas's with rubber gloves being "used, as a rule, for septic cases, to prevent the hands of the operator carrying infection, though, of course, clean cases are always, when possible, done before the dirty ones".⁹² Another motive for wearing gloves may have been to secure a degree of protection for the surgeon during operations on septic cases. That the hazards of this were real is illustrated by Lockwood's fate; he died from an infection contracted at the end of an operation on a patient with peritonitis.⁹³ Protection of the surgeon from blood and antiseptics was also a reason for the introduction of operating coats. Ogston lists one in the requirements for an operation in his 1889/90 notes,⁹⁴ a time when surgical practice in Aberdeen was still fully antiseptic; a photograph of an operation in the old pre-1892 operating theatre shows a carbolic spray and the surgeon and his assistant in white coats,⁹⁵ and a drawing in the 1886–90 medical students' graduation brochure⁹⁶ shows Ogston similarly attired, with the spray in operation. Operation coats were a well established feature of German and American practice in the late 1880s,⁹⁷ they pre-date the introduction of aseptic techniques. Their sterilization by heat required the development of steamers or autoclaves that left objects dry at the end of the sterilizing cycle, and the absence of such apparatus at St Bartholomew's in the early 1890s may explain why Lockwood restricted his recommendations on surgeons' dress to the provision of an unsterilized apron.⁹⁸ Blouses of the type described by Wallace at St Thomas's in 1899 had been in use in some centres in Europe for much of the decade.⁹⁹

The only operating theatre in the three hospitals to be designed *de novo* during the 1890s on aseptic principles was Cripp's at St Bartholomew's. In establishing a separate theatre for laparotomies he was following well established German practice. The American surgeon Paul Mundé in his 1886 paper on a tour of European clinics describes

⁹² Wallace, *op. cit.*, note 57 above, p. 320–1. Cost may have been a factor which placed a restriction on the free use of rubber gloves. In 1900 a pair of cotton gloves for operating cost 1s. 6d.; thin rubber gloves cost 3s. 6d. (*Medical annual*, 1900, advertisements, p. 667).

⁹³ See note 76 above. Schimmelbusch died from a septic infection at the age of 35 (W. Bulloch, *The history of bacteriology*, London, Oxford University Press, 1960, p. 395) and Clutton's "strength was sapped by two serious illnesses due to septicaemia from poisoned wounds about twelve years before his death" (see note 61 above); it is not clear from these accounts whether the infections were contracted at operations. For a detailed contemporary account of the risks at post mortems—which had similarities to those faced by surgeons operating on septic cases—and the precautions taken with particular reference to the hands, see T Shennan, *Post mortems and morbid anatomy*, London, Constable, 1912, pp. 5–8.

⁹⁴ Ogston, *op. cit.*, 36 above.

⁹⁵ Levack, Dudley, *op. cit.*, note 45 above, plate 32, p. 95.

⁹⁶ Student brochure, see note 31 above.

⁹⁷ Paul F Mundé ('A glimpse of laparotomy in

Europe', *Am. J. Obstet. Dis. Women and Children*, 1886, 19: 897–929) describes Schede of Hamburg operating in rubber shoes and linen coat in his laparotomy room at a temperature of 85° with the room full of aseptic vapour and the floor drenched with antiseptic fluid. For American coats see the painting by Thomas Eakin *The Agnew Clinic* (1889) reproduced in A S Lyons, R J Petrucelli II, *Medicine. An illustrated history* New York, H N Abrams, 1978.

⁹⁸ Lockwood, *op. cit.*, note 77 above, p. 162.

"The surgeon and his assistant remove their coats, turn up their shirt sleeves, and put on aprons to protect themselves from jets of blood or the splashing of lotion. If aprons be not at hand, towels serve this purpose very well. The apron, it is hardly necessary to say, not having been sterilized, must never be touched with the disinfected hands, or be allowed to touch the wound . . . our standard of personal cleanliness is so high in this country that directions which are sometimes given may be omitted."

⁹⁹ Illustration of gowns at the beginning of the 1890s can be found in Schimmelbusch, *op. cit.*, note 4 above, p. 179, and G Leopold, 'Über Beckenhochlagerung bei Laparotomien', *Centralblatt für Gynäkologie*, 1890, 14: 745–8.

laparotomy rooms in the private clinics of Prochownick in Hamburg and Martin in Berlin and, in public hospitals, in the clinics of Schede in Hamburg and Schroeder in Berlin.¹⁰⁰

There is no evidence that any original contributions to the techniques of asepsis were made in the three hospitals. Ogston had, of course, made novel and important contributions to the bacteriology of abscesses, his work adding to the already accumulating evidence that carbolic acid had only limited antibacterial powers. Lockwood also undertook original work, evaluative studies on asepsis using bacteriological techniques.¹⁰¹ Granshaw has suggested that the theory and practice of asepsis was the outcome of a synthesis between “cleanliness”—a system promoted as a superior alternative to antiseptics by George Callender of St Bartholomew’s—and the germ theory.¹⁰² The events at St Bartholomew’s described here lend no support to this idea. Butlin’s attempt to follow a line of practice that dispensed “with the strictest aseptic and antiseptic methods” might well have been influenced by Callender’s teaching. It ended in failure.

Evidence from the three hospitals suggests that the date of a surgeon’s training was a more important determinant of a surgeon’s attitude to asepsis than where it occurred. Thus Ogston and Butlin, who were born in the mid-1840s, moved slowly and cautiously in their adoption of elements of asepsis. Their initial training in surgery was in the pre-antiseptic era. Cripps and Clutton were both born in 1850 and received their basic training some years after the introduction of antiseptics. Their adoption of asepsis appears to have been quiet and painless. Lockwood was born in 1856, and, although eventually practising along mixed antiseptic/aseptic lines, promoted asepsis enthusiastically *via* bacteriology. His early medical education predated Koch’s work. Wallace and Gray were born in 1869 and 1870 respectively. Trained in schools with committed antisepticians and where bacteriology was taught enthusiastically, they were active proponents and propagandists of aseptic surgery *qua* surgeons.¹⁰³ These chronologies support the notion that the career development of a surgeon at this time could without difficulty support one

¹⁰⁰ Mundé, *op. cit.*, note 97 above. A photograph of Schede in his “Laparotomiesaal” with colleagues and assistants in the new Eppendorf Hospital in Hamburg is reproduced in U Weisser, *100 Jahre 1889–1989 Universitäts–Krankenhaus Eppendorf*, Tübingen, Attempto, 1989, p. 238.

¹⁰¹ The grants given to Ogston and Lockwood by the British Medical Association Scientific Grants Committee formed only part of the support provided by this body for work on antiseptics, and bacteriology in general. It supported studies by Watson Cheyne, and, in 1879, the year that it granted £50 to Ogston, it voted sums to Cossar Ewart “to continue his research into the life history and pathological relationships of specific organisms already known, and for the discovery of other similar organisms, and the channels through which they enter the system”, and to John Chiene “to continue his researches on the subjects 1. are there present in organs of living animals, particles which originate the bacteria met with after death? 2. Do the discharges from wounds which are antiseptically treated contain organisms?” (*Br. med. J.*, 1880, ii: 223).

¹⁰² L Granshaw, ““Upon this principle I have based a practice”; the development and reception of antiseptics in Britain, 1867–90” in *Medical innovations in historical perspective*, ed. J V Pickstone, Basingstoke, Macmillan, 1992. Granshaw’s review clearly demonstrates the substantial shifts in opinion regarding antiseptics and changes in Listerian practice that occurred in the last third of the nineteenth century, and also shows that the background against which these changes were occurring was itself variable. Even if Callender’s “cleanliness” method did not contribute directly to the development of the techniques of asepsis, the suggestion implicit in the review that it influenced the simultaneous evolution of surgical practice in other ways is an important one that should be investigated further.

¹⁰³ An indication of teaching at St Thomas’s and Aberdeen is contained in the extensive bacteriology sections of the textbooks published by teachers of pathology there; J F Payne (physician and joint-

major change in practice, but not two. An analogy can be drawn with the economist's hypothesis of the "disadvantage of an early start", which suggests that old capital embodying old methods hinders the adoption of new methods, and, paradoxically, having it is worse than having none at all. Hahn and Matthews have put it nicely for intellectual capital:

managers and workers who are very experienced in old methods of production may find it more difficult to learn improved methods than if they had no experience at all: there is a cost of demolishing their obsolete intellectual equipment. This tendency is likely to be more important relatively to its opposite, learning by experience, if technical progress is of a revolutionary rather than evolutionary nature.¹⁰⁴

Listerian Germ Theory and Asepsis

In their detailed discussion of Listerian germ theory and its evolution Christopher Lawrence and Richard Dixey argue that the major transformation—"a revolution even"—in surgery between the late 1860s and the 1890s did not derive "from a single sudden innovation engineered by a small group (the Listerians)" but came about "as the accumulation of many small deviations from intellectual and practical routine among the surgical community *as a whole*".¹⁰⁵ Evidence presented in this paper indicates that from the early 1880s modifications to Listerian practice were stimulated by work done by bacteriologists who used Koch's methods—some being surgeons as well—rather than by Lister and his close colleagues, and that after the middle of the decade a reaction against the toxicity and limited efficacy of antiseptics developed to become the main impetus behind the development of heat sterilization methods. Indeed, Lawrence and Dixey have shown in their analysis that the immediate response of Lister and Cheyne to the work of Koch and those who used his methods was not particularly positive, with Lister in the early 1880s being unconvinced "that all inflammation is caused by micro-organisms, and that suppuration, whether acute or chronic, is always due to similar agencies".¹⁰⁶

Nevertheless, Lister's original idea that the "disastrous consequences in compound fracture" were caused by the "germs of various low forms of life", "septic germs", "minute particles" which could behave towards complex organic compounds like the yeast plant was not rejected by later workers, and the properties and behaviour of these "septic germs"—later redefined as bacteria by size and metabolic activity in

lecturer in pathological anatomy at St Thomas's), *A manual of general pathology*, London, Smith, Elder, 1888, and D J Hamilton (Professor of Pathological Anatomy at Aberdeen), *Text book of pathology*, London, Macmillan, 1889 (vol. 1).

¹⁰⁴ F H Hahn, R C O Matthews, 'The theory of economic growth: a survey', *Econ. J.*, 1964, 74: 825–32, 836–50.

¹⁰⁵ C Lawrence, R Dixey. 'Practising on principle: Joseph Lister and the germ theories of disease' in *Medical theory, surgical practice*, ed. C Lawrence, London, Routledge, 1992, p. 207. This analysis of the writings of Lister and Cheyne describes the major changes that the theoretical basis of the antiseptic

system underwent during its development, and clearly shows that many accounts of its history are misleading in the way that they link Lister's ideas on the germ theory of putrefaction to the German germ theory of disease and the development of aseptic techniques. For a contemporary example of this phenomenon see T H Pennington, 'The contamination of ties', *Bri. med. J.*, 1994, 308: 417.

¹⁰⁶ J Lister, 'An address on the relations of minute organisms to inflammation', Transactions of the International Medical Congress, London, 1881, in *The collected papers of Joseph, Baron Lister*, Oxford, Clarendon Press, 1909, vol. 1, p. 400.

Listerism, its Decline and its Persistence

Pasteurian/Listerian fashion—continued to guide developments, especially those of asepticists hostile to antiseptics.¹⁰⁷ Lister told the British Medical Association in 1871,

do not let any statements, whether in books or in journals, shake your belief in the truth that putrefaction, under atmospheric influence, as it occurs in surgical practice, is due to particles of dust ever present in the atmosphere that surrounds our patients, and endowed with wonderful chemical energy and power of self-propagation, yet happily readily deprived of energy by various agents which may be employed for the purpose without inflicting serious injury upon the human tissues.¹⁰⁸

What was challenged in the remaining years of the nineteenth century was Lister's emphasis on the atmospheric source of the "self-propagating particles", and his belief that these particles could be "deprived of energy" by antiseptics "without inflicting serious injury on the human tissues". Nevertheless, the asepticists' belief in the importance of the particles was just as strong as that of the Listerians. It is thus difficult to accept Fox's thesis that their work was "based on a completely different theory".¹⁰⁹ The link between antiseptic and aseptic practice was clearly made by Kelly in 1886:

He believes it to be the great glory and the crowing triumph of *antisepsis* to have discovered *asepsis*. He has nothing in common with those surgeons who claim that antiseptics have done nothing . . . In a more advanced position, and the one in which the surgeon is living up to a principle, the utmost precautions are taken by a preliminary use of antiseptics in sufficient strength, and he goes to his operation needing no germicides.¹¹⁰

In the last lecture that he gave to medical students on the topic before he retired, Alexander Ogston—by now teaching a regime that was strictly aseptic—put it in a different way—"everything not *Disinfectant* but *Disinfected*. We can count usually on flesh and blood being aseptic—but not skin and what is good of adding carbolic etc. to wound making irritation".¹¹¹

The Persistence of Listerism

It is appropriate that Ogston's last public pronouncement on antisepsis should have referred to the direct application of antiseptics to wounds. Not only was it the first step taken by Lister in the evolution of antisepsis, when he treated James G—'s compound fracture of his left tibia on 12 August 1865—"My house surgeon, Dr Macfee, acting under my instructions, laid a piece of lint dipped in liquid carbolic acid upon the wound",¹¹² but it was the technique used when Listerian antisepsis was last applied on a large scale, by British surgeons during the First World War. In Henry Gray's words, "At the beginning of the war most surgeons were strongly imbued with the faith that antiseptics provided all that was essential for successful treatment of the appalling sepsis which faced them". His views on the antiseptic treatment of wounds torn by missiles

¹⁰⁷ Lister, 'On a new method', op. cit., note 7 above, p. 326.

¹⁰⁸ J Lister, 'The address in surgery', *Br. med. J.*, 1871, ii: 225.

¹⁰⁹ Fox, op. cit., note 5 above.

¹¹⁰ Kelly, op. cit., note 28 above, p. 1081.

¹¹¹ Robert Richards, notes of A Ogston's surgery lectures, 1908–9, Aberdeen University Library, MSU/U 1090/1.

¹¹² Lister, 'On a new method', op. cit., note 7 above, p. 328.

were direct—"Antiseptics affect bacteria imbedded in these no more than shrapnel or rifle fire dislodges the Hun lurking in fortified dugouts." After noting that "Sir Almroth Wright's able and stimulating work had much influence in gradually weaning the profession from the established faith, and in fostering reliance, so to speak, on the powerful natural reserves which can be called upon to cope with invading organisms", he concluded that "it is doubtful indeed whether, after proper operative treatment, a wound treated by antiseptic methods behaves any better than one treated by aseptic methods".¹¹³ These events provide powerful testimony to the enduring power and influence of Lister's ideas, also exemplified by the words of one of the official historians of surgery in the war published in 1922:

The local application of an efficient antiseptic, though not theoretically necessary, is the most powerful means at the disposal of the surgeon, to compensate for errors in procedures on his part which haste and the often unavoidable surroundings rendered practically inevitable.

Nevertheless, after his vigorous defence of antiseptics, the historian did acknowledge that "a small band of sturdy supporters of the "aseptic system", of whom Cuthbert Wallace was the leader, "maintained, however, an unwavering belief in the truth of principles they professed, in spite of the stress and turmoil of the struggle."¹¹⁴

¹¹³ H M W Gray, *The early treatment of war wounds*, London, Henry Frowde and Hodder and Stoughton, 1919, pp. 105–7.

¹¹⁴ G H Makins, 'Wound treatment in general

hospitals in France,' in *History of the great war, medical services, surgery of the war*, eds. W G Macpherson, A A Bowlby, C Wallace, C English, London, HMSO, 1922, vol. 1, pp. 306–7.