This paper analyses what is possibly the most important long-term impact of Joseph Lister’s method of antisepsis on surgery, namely its role in replacing surgery’s traditional regime of the management of chance by what can be called a regime of modern risk management. It was a crucial step for the expansion of surgery and thus the formation of modern surgery, as we know it today. It put surgery on a par with contemporary trends in industry, transport technologies and science, and made it a component factor in the formation of a modern technology-oriented society. The paper uses the example of the German-speaking countries, which, because of the rapid and emphatic acceptance of Lister’s antisepsis there, is particularly well suited for such an analysis. It shows how, in this context, risk management, as a way of dealing with uncertainty, was an integral part of the new techniques of antisepsis and asepsis.

**Keywords:** history of surgery; history of antisepsis; risk management; modernity

Until very recently the surgeon, at the moment of having skilfully finished his operation, was in the same position as the farmer after cultivating his land, only able to await the harvest and accept whichever way it turns out—sunshine, storm or hail—whereas today the surgeon is more like the manufacturer from whom, come what may, the public expects high quality products.

This is how the German surgeon Richard von Volkmann, speaking at the International Medical Congress in London in 1881, summarized the transformation of surgery in the previous 15 years. From the early 1870s Volkmann, who was head surgeon and professor in Halle, had been one of the most important proponents of Lister’s system in Germany. He used his London talk to announce that his mission had not only been accomplished but had led to a change ‘without parallel in the history of medicine’. Through knowledge of the cause and the nature of septic wound disease, surgeons had gained the power of controlling it, he stated. No longer would it be good luck versus bad luck that determined the success of surgery: henceforth it would be knowledge versus ignorance, capability versus incapability, diligence

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versus negligence that decided the outcome of operations. The antiseptic method had freed surgical practice from the rule of chance and raised it to the rank of an experimental science. The surgeon thus was no longer like a farmer at the mercy of the vagaries of unpredictable nature. He was now like a manufacturer who is in control of his production methods.

In this paper I use Volkmann’s declaration as a springboard to a discussion of how surgery’s traditional regime of the management of chance was replaced by a form of risk management—probably the most significant consequence of Lister’s work for surgery in the long run. As we shall see, adopting risk management strategies gave surgeons a new sense of security, which opened up the possibility of the expansion of operative surgery in terms of numbers and in terms of the invasiveness and complexity of its interventions. At the same time, surgeons felt that this development put surgery on a par with contemporary science, industry and transport technologies. It thus turned surgery into an important factor in the formation of modern technology-oriented societies and their particular way of dealing with uncertainty by defining it as risk.

For this analysis I shall put my empirical focus on the German-speaking countries. Because the new antiseptic method recommended by Lister was adopted much faster in Germany than elsewhere, the German experience is particularly well suited for studying its effect on surgeons’ concepts of power, responsibility and risk. Furthermore, in the last decades of the nineteenth century, German-language surgeons were the first to take the principles of both antisepsis and risk management to a higher level to develop asepsis and a new type of statistically grounded ‘safe surgery’. I first examine the adoption, spread and transformation of Lister’s antisepsis in the German-speaking world, followed by an analysis of how these processes went along with a redistribution of responsibility for surgical outcomes and how this resulted in new ways of dealing with surgical uncertainty through various forms of risk management.

ANTISEPSIS IN THE GERMAN-SPEAKING COUNTRIES

By the time of Volkmann’s London presentation, any serious opposition to Listerian antisepsis had ceased to exist, he claimed. But although true for Germany, it was not true for other countries, as his Berlin colleague Karl Langenbuch noted with astonishment in the report he wrote about the London congress.

The reasons for the favourable reception of Lister’s ideas in Germany were manifold. For one, the sense of crisis due to the rapid increase in wound disease, which had given rise to antisepsis in Britain in the first place, seems to have been even more acute in Germany. On both sides of the Channel, contemporaries observed that German surgical wards were less sanitary and practitioners less interested in cleanliness than their British counterparts. This can be explained by the predominance of the miasmatic theory, which postulated epidemic seasons and other influences beyond human control as causes of disease, which might have caused, as medical historian I. H. Upmalis claims, a more passive attitude among German surgeons. In addition, there seems to have been a relatively fast and steep increase in the number of surgical accident cases caused by the belated and intense industrialization that Germany underwent during the period of this septic crisis, which overburdened the existing hospital facilities. As result, the pressure to come up with a solution to this problem was higher, and the threshold for trying out unknown methods lower, than in other countries.
Acceptance of Lister’s methods might also have been easier in Germany than in Britain because, for German surgeons, Lister was an outsider. In Britain he was mired in local, regional and national rivalry, whereas in Germany Lister’s method was a foreign element on which practitioners could draw to strengthen their own position within the German-language sphere. And there were apparently fewer options to draw on than in Britain, where several systems of clean surgery were being developed; in contrast, in Germany the main alternative to antisepsis was open-wound treatment, which had dominated the discussion for the two previous decades.  

There were probably also structural reasons that made it easier for a demanding and precarious technique to be adopted. In Germany the trend of relocating surgery in hospital environments seems to have been stronger. Elite surgery was performed mostly at the universities, with their large hospitals and a strong and hierarchically organized surgical staff, conditions that facilitated the controlled spread of the technique.  

Finally, as historian Michael Worboys claims, in Germany Listerians worked ‘with the grain of advanced medical science rather than against it.’ German doctors found it easier than their British colleagues to accept and integrate new ideas that were based in laboratory science. In a medical culture in which experimental science carried high prestige, the notion that the patient body was in significant ways comparable to a bacterial culture in the laboratory was a natural step to take.  

Volkmann was one of a number of German surgeons who early on had tested Lister’s method, but he was not the first. In Leipzig, Karl Thiersch had tried out the technique immediately after the publication of Lister’s first article in 1867, and being the head of an academic department and thus a typical exponent of the German system, he had one of his students write his doctoral thesis on a case series of complicated bone fractures and abscesses successfully treated with Lister’s antisepsis. However, the benefit of the new method remained debatable, and other surgeons claimed that similar results could be achieved without it. The Franco-Prussian war in 1870 would have been an opportunity to use Lister’s method because it produced a large number of casualties, many of whom succumbed to wound disease, often from minimal injuries. But even though Lister’s 1870 paper on the use of antisepsis in war surgery was immediately translated into German, the method was not widely adopted in the war. Many German surgeons remained sceptical and up until 1872 there were only sporadic attempts to practise Lister’s treatment.  

The breakthrough came with two key publications in 1872 and 1873. Their authors, A. W. Schultze and L. Lesser, had visited Lister and brought the technique back with them. Their detailed descriptions in German made Lister’s antisepsis methods accessible and replicable by their German colleagues, and in 1872 the first congress of the newly founded German Society of Surgery put antisepsis on its agenda, further contributing to its propagation.  

Having recently returned from the Franco-Prussian war, Volkmann also became interested in antisepsis. He was surprised that the appalling surgical results he had seen during the war now occurred in peace time in his home town of Halle. As a result of the soaring numbers of casualties in the city’s rapidly growing industrial sector, his hospital, which had originated from the pre-industrial era, had become seriously overcrowded; wound disease was escalating, and mortality from amputation and complicated fractures was increasing year on year. Initially, open-wound treatment worked well, but then results started to deteriorate. By 1872, 37–41% of patients with complicated fractures were succumbing, with pyaemia and erysipelas in the previous year claiming so many lives that Volkmann considered closing down the institution. Industrialization had a large role in the
culmination of this septic crisis, as shown in Volkmann’s case histories, which are replete with injuries from industrial and railroad accidents. His report was representative of the German experience: in 1872 mortality from wound disease in Germany ‘varied from hospital to hospital but in nearly all of them it was between 38–42% regardless of the method of treatment.’ A parallel situation developed in Munich: Johann Nepomuk Nussbaum described how his surgical wards had been infested with pyaemia for decades. By 1874, 80% of all wounds were afflicted with hospital gangrene. Erysipelas could be found in almost every bed and nobody had apparently ever seen a wound heal by first intention (that is, without inflammation, breakdown and resulting scar tissue). ‘Horrible was our trade!’ Nussbaum later exclaimed. Reports such as these convey a sense of acute crisis in the face of an increase in septic complications of epidemic dimensions. Surgeons felt they had lost any control over the outcomes of their work.

Many surgeons in Germany actively looked for some way out of what was seen to be an unprecedented crisis. In his desperate search for ways to improve these dismal mortality rates, Volkmann tried antisepsis, expecting it to be an experiment that would last at most a couple of weeks. But to his surprise antisepsis turned the situation around completely. Increduously, Volkmann watched his patients’ wounds heal beneath the carbolic acid dressings without complications. At the point when he took up antisepsis, the previous 12 patients with an open fracture of the lower leg all had died from pyaemia or septicaemia. He subsequently treated a series of 135 open fractures with antisepsis and by 1881, when he gave his talk in London, not one of them had succumbed to wound disease.

The healing process beneath a Lister dressing seemed to be unlike anything that surgeons had seen before: wound secretion was sparse, healing by first intention became the norm, and the occurrence of wound disease became the exception. This reduced mortality was also accompanied by far less morbidity, decreased pain, a shorter period of hospitalization and little or no fever and suppuration. Volkmann reported that more patients survived thigh amputations in the course of one year than had done in the course of his entire career up to then. For him antisepsis represented the greatest progress in surgery since the inception of the craft.

In parallel with Volkmann’s practice, Nussbaum had started using Lister’s method in his Munich surgery department on 1 January 1875. Four years later, in his textbook on antiseptic method, he recorded that not a single case of hospital gangrene, pyaemia or erysipelas had occurred, and general mortality had been cut in half. For Nussbaum, too, Lister’s antisepsis was the greatest invention ever made in surgery. It had eliminated all the problems of wound disease ‘as if by magic’ and ‘saved the life of thousands’. Nussbaum emphasized that this improvement was ‘no coincidence. . . . All of the conditions—the rooms, the furniture, the food, the care, the number of patients—everything else had remained the same, only wound treatment had changed’. To Nussbaum, the changes were so clear ‘that one would have to be blind not to be converted to antisepsis’. Even for historians today, Nussbaum’s and Volkmann’s reports provide strong evidence in favour of the effectiveness of Lister’s antiseptic measures of the time.

Historians and contemporary observers agree that Volkmann’s advocacy was instrumental in converting German-language surgeons to antiseptic surgery. As a well-respected leader of the profession who advocated antisepsis on the basis of a profound knowledge of the method and personal experience, his support for Lister’s system was unwavering. When Lister came to Germany in 1875, although it was a great personal triumph it was no longer important for the dissemination of his method in that country. As Upmalis
concludes: ‘By 1875 the battle between the supporters and opponents of Lister’s treatment seems to have been won by the former.’

At his next visit to the country, on the occasion of the Tenth International Medical Congress in Berlin 1890, Lister was celebrated as a benefactor of humankind; he and the German national heroes Rudolph Virchow and Robert Koch were heralded as the triumvirate of leading men of contemporary medicine. The acceptance of Lister’s method in Germany had an effect beyond the German-speaking world, as Lister’s biographer Rickman John Godlee understood: ‘German surgeons were numerous, energetic, and very prolific and persuasive writers’, he wrote in 1909; ‘their influence upon the rest of the world was undoubtedly great, and, to some extent, the rest of the world waited to hear what their verdict would be.’

**KNOWLEDGE TRANSFER**

The spread of the new technology had depended very much on personal transmission. Thiersch had sent his assistant to Edinburgh to learn the method from Lister directly, and Schultze and Lesser had also spent some time with the master. Schultze reported in 1872 how the quality of the method’s application decreased with increasing distance from Edinburgh. Already in Glasgow many surgeons were not following all the details of Lister’s methods correctly, and their results were accordingly inferior. In other places in the British Isles the quality of the practice declined even further, and it was lowest in London, where the leading surgeons ignored Lister’s technique altogether. In mainland Europe the situation was no better: Schultze noted that the technique was not used correctly in Holland, Belgium, south Germany or Vienna. His colleagues in these countries were ignorant of the technical details of the method, most of them thought that Lister’s technique consisted merely in the application of carbolic acid to the wound, and accordingly they remained sceptical about its effectiveness.

The viability and credibility of antisepsis were closely associated with its correct use: ‘The most thorough attention to the smallest details is necessary in Lister’s method’, Schultze urged, ‘to achieve the favourable results that doubtlessly exist.’ Judgement about its usefulness was only legitimate if the ‘operations had been performed truly antiseptically.’ Volkmann, too, emphasized that the new method had to be followed rigorously, which was not easy, especially because tacit knowledge—the right touch—seemed to have a decisive role. Individual surgeons seemed to fare like individual housewives in their efforts at making fruit preserves, Volkmann remarked, some always being successful, others regularly having a high share of spoiled jars. Little, unnoticed details could be decisive. In making fruit preserves it made all the difference, Volkmann argued, whether the sulphurized glasses were erroneously kept upright instead of turned upside down as they should be and the situation was similar in antisepsis. In a subsequent letter, the Swiss surgeon and later Nobel laureate Theodor Kocher of Berne took up the housewife analogy and asked Volkmann if he could come to watch him apply Lister’s methods in person to avoid ending up like some preserve-makers who always spoil their fruit products—another allusion to the importance of personal transmission of knowledge and skill.

The price to be paid for the effectiveness of the new technique was painstaking attention to its details. ‘None of the methods hitherto known required more practice, industriousness,
and thoroughness than Lister’s’, Nussbaum emphasized, declaring that ‘the secret of Lister’s treatment lies in pedantic accuracy.’ At that time, pedantry was not necessarily part of the surgeon’s persona, and in his textbook Nussbaum found it necessary to defend against possible ridicule by his colleagues. Antisepsis demanded more effort, practice and diligence than any other known method in surgery, he explained, because half measures here would result not merely in half the gain, but in no gain at all. With antisepsis, its adoption was all or nothing. The challenge was less its technical complexity than its inherent precariousness, which required ‘constant and uninterrupted attention’. Even under optimal conditions, good results could not be expected right away. Any judgement about the new method had to take into account a learning curve that novices needed to go through. One could not, Volkmann mused, ‘expect from the first day the same regularity of success that someone who is familiar with the method can achieve.’ During his first year, results were not as good as later on, because he had not yet invested the time and energy required to familiarize himself with the new theory and technique. Good results could be achieved only by subordinating himself completely to Lister’s prescriptions and resisting modification resulting from the temptation to do a better job than Lister himself. At this stage, all efforts had to be focused on faithful replication. Any modifications were for later, Volkmann stressed.

By 1875 the principles and the technical details of antisepsis seem to have become common knowledge in Germany. Papers published after this date no longer deal extensively with these points but begin to advocate modifications of the classical Lister treatment, an indication that the technique had been mastered and accepted. German surgeons now thought they could achieve antiseptic security ‘without the cumbersome ballast of the Listerian method of dressing’, as one of them put it. This attitude was emblazoned in the slogan ‘Fort mit dem Spray’ [Away with the spray], which Victor von Bruns chose as the title of a paper of 1880, referring to Lister’s use of carbolic spray to disinfect the air around the surgical wound. By 1883 German surgeons had, for the most part, abandoned the original Listerian procedure and replaced it with their own versions of antisepsis so that there were ‘as many modifications of it as there were surgical clinics’.

THE EFFECTS OF ANTISEPSIS ON SURGEONS’ ATTITUDES

The adoption of antisepsis went along with an unprecedented expansion of the surgical realm. One did not need to be a surgeon, Volkmann stated, to see the change: ‘Operations that just 15 years ago would have been considered insanity or a crime’ were now being performed on a routine basis without detriment to the patient. The confidence engendered by the new technique shaped the mentality of a whole generation of surgeons. Crowther and Dupree have noted for the English-speaking world that it gave ‘practitioners at all levels immense confidence in the future of surgery’, which convinced radical surgeons ‘that with the science of bacteriology they could conquer most of man’s ills eventually,’ as Peter English found for the USA. In Germany the change of mentality occurred within a period of only a few years. As recently as in the great wars of 1866 and 1870, Volkmann explained, surgeons still followed the precept that any operation was dangerous and to be avoided if at all possible, an attitude that disappeared with a new generation of surgeons possessing ‘faith in the infallibility of the antiseptic principle and courage that has not been crushed by failures’. These young colleagues dared to tackle
operations that ‘not even the most audacious surgeon would have thought of, and achieve results, about which he can only shake his head’.\textsuperscript{55} They could be so daring because they knew ‘of the sad experiences of the old surgery only as legends’.\textsuperscript{56}

It is important to note that it was not the expansion of surgery as such that was seen as the main advantage offered by antisepsis, but rather the predictability and uniformity of its outcome: ‘The treasure we have found is certainty. It is wonderful to be allowed to say that it is not a coincidence any more if a wound heals safely and quickly’,\textsuperscript{57} Nussbaum stated, Volkmann noting that the worst aspect of the pre-antisepsis crisis was the utter unpredictability of outcomes. No surgeon, however experienced, was able to predict whether an injured patient would survive, even if his or her injuries were banal.\textsuperscript{58}

In his 1881 speech Volkmann emphasized the newly found certainty. He explained that the radical change in surgery in the preceding 15 years had been precipitated by the knowledge that ‘all the uncountable and unpredictable disturbances that threatened the wounds and with it the lives of operated and injured patients are only the consequence of specific processes of corruption in the body fluids which are being mediated by the intrusion of low organisms’—a formulation, in other words, of the germ theory of wound disease. With such knowledge came power:

\begin{quote}
With the knowledge of their origin and the understanding of their nature, we have simultaneously gained the power to prevent these disturbances. Through purposeful action we are capable of paralyzing the pernicious activity of these microorganisms. From now on the fate of an uncountable number of sick people has been laid in our hands.\textsuperscript{59}
\end{quote}

This new responsibility was seen as a radical departure from the previous situation, when surgical results were seemingly independent of the quality of their treatment. Even the best surgeon could never guarantee the favourable course of a wound’s healing process. He had had, as Volkmann phrased it, ‘the sad privilege’ of being unaccountable and uncontrollable.\textsuperscript{60}

This sad privilege confronted surgeons with the challenge of dealing with the inherent unpredictability of the consequences of their work. An essay of 1854 entitled ‘On Luck in Surgery’ and written in German by the Russian surgeon Nikolay Pirogov helps us to understand this pre-antiseptic quandary. Starting from the assumption that outcomes are essentially uncontrollable, Pirogov discusses how surgeons can protect themselves from being blamed for bad results that occur without their fault. This was necessary because nobody was blessed with consistent good luck or possessed ‘the superhuman gift of divination’.\textsuperscript{61} Because of this, practitioners needed to choose the right conditions for surgery, a task that required a particular type of practical tact, a highly personalized mixture of talent and deeper knowledge,\textsuperscript{62} the skill of judging whether or not to take a risk in a situation in which the odds were predetermined but could be neither influenced nor completely known.\textsuperscript{63} The right decision depended on a whole economy of risk and judgement, in which medical and non-medical factors had a role. Thus patients of high social rank, such as aristocrats, represented a particularly high hazard to the surgeon’s reputation in case something went wrong.\textsuperscript{64} The surgeon had to act with the greatest possible circumspection when choosing cases. Sometimes difficult cases had to be transferred to more experienced colleagues, or patients had to be advised against surgery altogether.\textsuperscript{65} Another strategy of reducing the threat to the surgeon’s reputation consisted in involving several doctors in the patient’s care, thereby spreading responsibility. Still another strategy was to perform a large number of relatively safe operations, so that the occasional failure had hardly any impact on mortality statistics. However, all these
strategies, Pirogov warned, were of limited use because the power of pure chance and of unknown hidden factors ‘often make their appearance in such a way as to paralyze all these wonderful qualities.’\textsuperscript{66} The use of statistical calculations, Pirogov thought, was not applicable to the surgeon’s day-to-day work, because of the chance element involved in probability calculations.\textsuperscript{67}

The introduction of antiseptic surgery transformed completely the logic of responsibility: ‘As long as a wound could turn bad even with the most correct treatment and kill the patient, responsibility was not high’, Nussbaum explained. But once surgeons knew how to protect a fresh wound with certainty from disaster, ‘the fortune of the injured lies almost completely in the hand of the person who treats him first, and his responsibility has become very high indeed’.\textsuperscript{68} ‘Now that we have eaten from the Tree of Knowledge, we are more closely bound up with the suffering of our fellow humans, and Providence has placed the main part of her previous responsibility into the hands of the surgeon, hands, which, more than ever, can spread blessing or curse’,\textsuperscript{69} Langenbuch eloquently reported on Volkmann’s talk in London. Volkmann saw this attribution of responsibility to the surgeon as emancipation from blind fate and innocence, opening ‘an enormous chasm separating us from the old surgery. We no longer decline having our capability completely measured by our success.’\textsuperscript{70} After the ‘triumphal advance’ of the ‘new and difficult treatment method’,\textsuperscript{71} the surgeon was fully accountable for any disturbance of the wound.\textsuperscript{72} But antisepsis not only put a new burden on the surgeon’s shoulder, it also made it possible to bear it, as Volkmann expressed: ‘We all know that a great responsibility rests on us, but we also know that with honest will and technical knowledge and with the application of all our strength we are capable of meeting it.’\textsuperscript{73}

**RISK MANAGEMENT VERSUS MANAGEMENT OF CHANCE**

Historians have described the emergence of an optimistic and activist approach to surgery in Britain and the USA, noting how new antiseptic and aseptic technologies allowed surgeons ‘to accept full technical and moral responsibility for the patient and their treatment. This made surgeons heroic both practically and morally, a position that befitted their professional self-image as the coming men of medicine’,\textsuperscript{74} Worboys states, characterizing the Listerian surgeon’s ‘emerging ideology and professional orientations’ as distinct from his pre-Listerian predecessor, who ‘saw the origin of sepsis as largely beyond his control’. The pre-antiseptic role ‘was to try to modify a pre-set pattern of morbid changes by helping the patient’s body counter the internal spread of infective poisons. Prior injuries, the peculiarities of the individual patient’s constitution and a host of other contingent factors limited the surgeon’s responsibilities.’\textsuperscript{75} By contrast, ‘the ideal Listerian surgeon was proactive, less fatalistic and took upon himself greater obligations’. ‘If they acted early and with precision,’ Listerians thought, ‘then most wounds were treatable. With wounds from elective operations, Listerians assumed that septic disease was avoidable and that any failures were the surgeon’s responsibility.’\textsuperscript{76}

We can go one step further and describe the change in attitude as a switch from a regime of the management of chance to a regime of risk management. I am using the term risk management to characterize a particular strategy of dealing with uncertainty. It consists in trying to calculate and control the odds of potential harm occurring. In post-antisepsis surgery, for example, the occurrence of wound disease is understood in principle as something that one can quantify, predict and control.\textsuperscript{77} Importantly, the rationale of risk
management revolves around human agency. The damage that occurs is seen as the consequence of one’s own decision, to be influenced by using technologies of risk control.\textsuperscript{78} For rendering the negative side effects of new technologies more predictable and controllable, decision-making processes are based on processes of documentation, calculation and regulation. As we have seen, surgeons adopted elements of this approach when they started using antiseptic methods, trying to convert the capricious, uncontrollable danger of surgical operations into a calculable and controllable risk. This strategy situates modern surgery in the context of contemporary developments in industry and traffic, as contemporary surgeons themselves noted when they integrated surgery into the new modern world order, exemplified in science, industry and transport technologies.

This is the deeper sense of the image of the farmer and the industrialist pressed into service by Volkmann in the quote at the beginning of this paper. A few years earlier he had used similar imagery when discussing the rare breakdown of control in antiseptic surgery. Such breakdown cannot be attributed to a deficiency of the antiseptic method, he claimed; the method itself offered absolute protection, but this protection only reached as far as the reliability of the surgeon in charge. The person of the surgeon became the weak element in the system. This makes surgery similar to science and industry, Volkmann explained: in physics or chemistry experiments ‘even the best skilled hand sometimes makes an error, in the same way that manufacturers sometimes experience failure in the fabrication of a product that they had made hundreds of times in the same, reliable quality.’\textsuperscript{79} It is significant that Volkmann put surgery in one category with science and industry to discuss the unavoidability of some residual risk due to human imperfection. Lister’s invention had put surgery on a par with science and industry, making it an instance of modern risk management and another example of the emergence of the risk concept as a ubiquitous feature of modern societies.\textsuperscript{80}

\textbf{Asepsis and Risk Management}

The adoption of antisepsis with its redistribution of responsibility was not the end of the trajectory of surgical risk management in the German-speaking countries. In the 1880s, a new generation of German-speaking surgeons tried to perfect antiseptic surgery by excluding pathogenic agents from the wound in the first place—an approach that came to be called ‘asepsis’. Asepsis was based on a ‘realignment of surgery and laboratory science’, in which surgeons systematically used the bacteriological laboratory as a resource for finding new and better ways of avoiding wound infections in the operating room. Surgeons collaborated with bacteriologists and set up their own bacteriological laboratories; some of them even acquired a double qualification in surgery and bacteriology.\textsuperscript{81}

One of the early proponents of this new approach was Ernst von Bergmann. When Bergmann gave his inaugural speech as head surgeon of the University Hospital in the Ziegelstrasse in Berlin in 1882 he linked his commitment to surgery and laboratory science to the ideas of control and responsibility. To make his point he referred back to his own experience of surgery’s past regime of chance management: ‘When I performed my first operation’, before the introduction of antisepsis,

\begin{quote}
I knew that only the ‘bloody act’ of the operation itself was in my hands, the size of the cut, the quality of haemostasis etc. Once the operation was over, the surgeon, not knowing
\end{quote}
how and why his patient would die after the operation was as powerless as the French monk and stonecutter frère Jacques Beaulieu in the 17th century, who told his patients ‘l’opération est achevée—que Dieu vous guérisse’ [the operation is done, may God heal you].

For Bergmann, surgeons before antisepsis were like the lithotomists of the seventeenth century, whose success was a gift from God, not a result of their own doing. Surgeons were ‘without merit for a favourable outcome and without blame for a fatal outcome’, he stated, but this had all been changed by antisepsis. Knowledge of the cause of the ‘so-called accidental wound diseases’ gave surgeons the power actively to avert damage to their patients and assume full responsibility for the ultimate outcome of their operations.

Bergmann claimed that even more strength could be derived from the laboratory. It was animal experimentation, not clinical experience, that would teach surgeons how to make wounds heal without danger. To reach this goal, surgeons needed to apply Robert Koch’s theory of specific aetiology and the experimental methods that came with it. Even though clinical observation had already pointed to an infectious aetiology for those diseases, the actual proof of causality could be accomplished only under the controlled conditions of the experimental laboratory, a place where diseases can be produced in healthy organisms by inoculating them with specific bacteria. The laboratory was a resource that Lister had hitherto not used appropriately, Bergmann pointed out, claiming that the Listerian system was based on the assumption, not on the proof, of the bacterial aetiology of wound diseases. But despite its shortcomings, Lister’s method had achieved an enormous improvement in surgical results. How much more could be expected from an accurate and precise analysis by bacteriological means?

To put his programme into reality, Bergmann systematically recruited surgeons with special expertise in experimental bacteriology. His assistants performed the laboratory work, whereas he made himself responsible for transferring new scientific knowledge into clinical surgery. This was to become the pattern in German university surgery of the 1880s and 1890s, in which a whole generation of bacteriologically trained academic surgeons emerged, his most influential student being Kurt Schimmelbusch. In 1892 Schimmelbusch published his ‘Guide to Aseptic Wound Treatment’, which rapidly became the authoritative reference work for the new technology. In this guide, Schimmelbusch spread Bergmann’s control ideology: even the most extensive operations, he explained, were now performed with such a degree of certainty that the surgeons did not even reckon with failure. No more was there good or bad luck in surgery (Schimmelbusch cited Pirogov as an example of the old regime of chance management) but instead the patient’s destiny lay in the hands of the person who performed the operation and dressed the wound. A death caused by wound inflammation after an amputation, for example, should no longer occur. The old adage coined by Ambroise Paré, ‘je le pansays, Dieu le guarit’—I bandaged him, God cured him—had ceased to be the involuntary motto on the operating doctor’s coat-of-arms. Here, Paré was given the role of the pre-modern, powerless surgeon (a figure used usually in the opposite way as an example of early surgical progress). To reiterate his point, in the subsequent passage Schimmelbusch cited Volkmann’s comparison with the powerless farmer and the manufacturer from whom the public demands good products.

Other proponents of aseptic surgery expanded on this type of comparison. In the 1890s one of the most influential surgeons of his generation, the Breslau head surgeon Johann Mikulicz, had found in his bacteriological investigations that the quality of hand disinfection not only varied from person to person, but even varied in one and the same
surgeon at different times—a finding that led him to raise the question of trust and responsibility: ‘Are we permitted’, he asked, ‘to let the welfare and life of the sick entrusted to us depend upon such uncontrollable contingencies?’ And he went on to add a fundamental thought about risk control and technology in what he called ‘the increasingly technical art of surgery’: ‘In the same way as in other areas of technology—in the operation of railways, in mining and in the metal industry—it can be demanded of us that we improve as much as possible the arrangements for the safety of the people who are entrusted to us.’ Mikulicz thus identified surgery as one of the modern technologies that came with a particular risk potential and demanded a regime of risk management in keeping with those used in transport and industry.

Laboratory science and the certainty it produced became common reference points for surgical risk management strategies. Surgeons took up an approach that the physiologist Claude Bernard had proposed earlier in the century. Bernard had argued that control of body function must first be achieved in the laboratory and then extended to the clinical context. In this way therapeutic measures would become as controllable and predictable as laboratory phenomena. Along these lines, Anton von Eiselsberg in Vienna in 1914, for example, stated that he had performed his thyroid transplants ‘in analogy to the animal experiment.’ Surgeons explicitly compared the certainty of success of new treatments with the replicability of a physiological experiment. Theodor Kocher in 1909 stated that a ‘physiological remedy’ for deficient thyroid function could lead to ‘a real cure . . . with the reliability of a physiological experiment’ and claimed that he had applied this principle when first he transplanted the thyroid in 1883.

Kocher is interesting in another way: his work on the removal of goitres is a striking example of the quantification aspect of the risk management approach. When these operations were first introduced in the 1860s they had a death rate of 40%. Kocher brought mortality down to 14% in 1882 and 0.5% in 1906. His documentation was similarly remarkable: in 1883 he reported his first 100 strumectomies, in 1889 an additional 250 and in 1895 his first 1000 cases, followed by 2000, 3000 and 4000 in 1901, 1906 and 1909, respectively. Statistics like these made it increasingly possible to use risk as a statistical parameter expressed in terms of numerical probability and to present the dangers of surgery as calculable, predictable and manageable.

Surgeons paired the certainty created through such statistics with Bernard’s scientific determinism, a determinism positing that the laws of nature fix completely the outcome of an experiment, the only variables being the experimental conditions. In the same way, surgeons saw the outcome of a surgical operation as dependent entirely on the conditions of the surgery. This utopian ideal of control became a common theme in twentieth-century surgery. If surgeons controlled all the conditions under which they worked, wrote Martin Kirschner in 1931, they would actually be able ‘to predict the outcome [of an operation] . . . The justifiable sense of certainty about the ultimate outcome of our surgical procedures is the result of the technical observance of the recognized laws of modern surgery.’

In his textbook of 1907 Kocher stated that a surgeon was able to guarantee a good outcome as long as he had complete control of the situation, for example over the equipment and the personnel involved. If this condition were fulfilled, he would be able to provide full safety, and be able to reply ‘no, there is no danger’ to a patient’s question about the danger of an operation. Kocher’s certainty about his concept of ‘safe surgery’ was grounded in scientific determinism combined with the statistical documentation of his surgical success. Interestingly, by using statistical calculations as an argument for the
safety of his operations Kocher did exactly what Pirogov in 1854 had declared to be impossible, and thereby provided an impressive indication of the extraordinary changes that surgery had undergone in the previous half century.

CONCLUSION: SURGERY AND MODERNITY

In this paper I have shown how the adoption of Lister’s antiseptic surgery by German surgeons switched the management of chance towards a recognizably modern regime of risk management. This reorientation was not a simple change of ideas. From the start, there was a close interrelationship between the new practices of antisepsis and asepsis and new ways of conceptualizing the negative outcomes of surgery. The definition of risk became built into the technologies shaping their evolution and vice versa. The use of antisepsis and asepsis did not eliminate wound disease altogether, nor did risk management eliminate uncertainty about surgical outcomes. But adopting particular rationalities of risk management gave surgeons new ways of dealing with uncertainty that increased their own and society’s trust in operative surgery. To be sure, the type of generalized information that such an approach produced always remained controversial even within surgery, but it functioned—and continues to function today—as a powerful line of argument.

With this move, surgeons placed themselves in the context of other growing technologies, and post-antisepsis surgeons began to view themselves as the equals of scientists, manufacturers, engineers and train operators, while placing their pre-antiseptic colleagues in another category completely, along with seventeenth-century barber surgeons, traditional stonecutters and farmers. Surgery had become part of technological modernity, participating in and even shaping the specifically modern way of conceptualizing risk. Like industrial production and the railroad—the nineteenth century’s iconic technologies of modernity—modern surgery was burdened with a certain risk. But in the same way in which the risks of industry and transport could be defined and constrained, surgical risk could be made amenable to technical control and management. With its specific way of redistributing responsibility and ascribing trust, the risk management approach has made modern surgery both viable and acceptable.

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NOTES

3 Ibid.


Upmalis, *op. cit.* (note 5), p. 222. Historians agree that industrialization occurred 50–70 years later in Germany than in Britain, starting in about 1840, so that one can expect its impact on the accident rates and forms to reach a peak in about 1870. Some historians even identify precisely the period before the adoption of antisepsis, 1848–1873, as the start phase of the German industrial revolution; see Flurin Condrau, *Die Industrialisierung in Deutschland* (Wissenschaftliche Buchgesellschaft, Darmstadt, 2005), pp. 21–27.


Volkmann, *op. cit.* (note 18), pp. 775–778.

Volkmann, *op. cit.* (note 1), 1884.

Volkmann called this type of wound healing ‘a-septic’, since no septic phenomena occurred, which does not mean that there were no germs. He even noted that his observations were not necessarily a confirmation of the ‘parasitic hypothesis’, his word for germ theory, especially because, even with the antiseptic method, micrococci could be found in the wound secretions on a regular basis. The reception of Lister’s antisepsis was thus not strictly bound to an acceptance of germ theory at this point: Volkmann, *op. cit.* (note 5), at pp. 762–774.
27 Volkmann, op. cit. (note 22), p. 924.
28 Nussbaum, op. cit. (note 20), p. 3.
29 Ibid., p. 4.
30 See, for example, William George MacCallum, William Stewart Halsted, surgeon (Johns Hopkins Press, Baltimore, MD, 1930), pp. 23–24.
32 Ibid., p. 233. For a contemporary voice see, for example, Theodor Kocher, ‘Bericht über eine dritte Serie von 5 Overariotomien’, CorrBl. Schweiz. Ärzte 7, 6–10 (1877).
36 Schultze, op. cit. (note 10), pp. 312–313.
37 Ibid., p. 306.
38 Ibid., p. 309.
41 Nussbaum, op. cit. (note 20), p. 27.
42 Ibid., pp. 8–9.
43 This is a general phenomenon in surgery; see Thomas Schlich, Surgery, science and industry: a revolution in fracture care, 1950s–1990s (Palgrave, Basingstoke, 2002), pp. 65–85.
44 Volkmann, op. cit. (note 5), p. 792.
45 Ibid., 1883.
46 Ibid., pp. 792–794.
55 Ibid., p. 1886.
56 Ibid.
58 Volkmann, op. cit. (note 22), p. 924.
59 Ibid., pp. 1877–1878.
60 Ibid., p. 1892.
über die wichtigsten Gegenstände der praktischen Chirurgie, pp. 22–111 (Breitkopf & Härtel, Leipzig, 1854), at p. 23. I thank Eberhard Wolff and Ursula Reis at the Institute for the History of Medicine of the University of Zürich for making Pirogov’s essay accessible to me.

62 Ibid., p. 31.
63 Ibid., pp. 28–29.
64 Ibid., p. 30.
65 Ibid., pp. 26–27.
66 Ibid., p. 32.
68 Nussbaum, op. cit. (note 20), pp. 6–9.
69 Langenbuch, op. cit. (note 4), p. 32.
70 Volkmann, op. cit. (note 1), p. 1891.
71 Ibid., p. 1880.
72 Ibid., p. 1892.
73 Ibid.
74 Worboys, op. cit. (note 9), p. 189.
75 Ibid., pp. 106–107.
76 Ibid., p. 107.
78 Niklas Luhmann, Risk: a sociological theory (A. de Gruyter, New York, 1993), pp. 1–31. Luhmann speaks of ‘danger’, as opposed to ‘risk’, if the potential damage is attributed to causes outside one’s own control.
80 Surgery contributed to the emergence of the modern risk society as characterized by Ulrich Beck, Risikogesellschaft. Auf dem Weg in eine andere Moderne (Suhrkamp, Frankfurt am Main, 1985), because the surgeons’ new confidence has led to the expansion of surgery and thus to the production of risk through technical progress, described by Beck as a feature of ‘reflexive modernity’.
82 The example of the supposedly pre-modern surgeon and the quote with God as in power of the healing process was used not infrequently by surgeons at the time. Pirogov used it in 1854 in his essay as an example of a pre-modern surgeon whose lack of technical sophistication made him practically more successful; Pirogov, op. cit. (note 61), pp. 24–25.
84 Ibid., p. 678.
85 Ibid., p. 702.
87 Curt Schimmelbusch, Anleitung zur Aseptischen Wundbehandlung (Hirschwald, Berlin, 1892), pp. 2–3.
For examples from the second half of the 20th century see Schlich, \textit{op. cit.} (note 43), pp. 86–109.


Theodor Kocher, \textit{Chirurgische Operationslehre}, 5th rev. edn. (Fischer, Jena, 1907), at p. vi.

