SPECIAL ARTICLE

Anesthesia and World War II: When the Battlefield Becomes a Research Field—A Bibliometric Analysis of the Influence of World War II on the Development of Anesthesiology

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At the outbreak of World War II (WWII), anesthesiology was struggling to establish itself as a medical specialty. The battlefield abruptly exposed this young specialty to the formidable challenge of mass casualties, with an urgent need to provide proper fluid resuscitation, airway management, mechanical ventilation, and analgesia to thousands. But while Europe was suffering under the Nazi boot, anesthesia was preparing to rise to the challenge posed by the impending war. While war brings death and destruction, it also opens the way to medical advances. The aim of this study is to measure the evolution of anesthesia owing to WWII. We conducted a retrospective observational bibliometric study involving a quantitative and statistical analysis of publications. The following 7 journals were selected to cover European and North American anesthesia-related publications: *Anesthesia & Analgesia*, the *British Journal of Anaesthesia*, *Anesthesiology*, *Schmerz-Narkose-Anaesthesie*, *Surgery*, *La Presse Médicale*, and *The Military Surgeon* (later *Military Medicine*). Attention was focused on journal volumes published between 1920 and 1965. After reviewing the literature, we selected 12 keywords representing important advances in anesthesiology since 1920: "anesthesia," "balanced anesthesia," "barbiturates," "d-tubocurarine," "endotracheal intubation," "ether," "lidocaine," "morphine," "spinal anesthesia," "thiopental," "transfusion," and "trichloroethylene." Titles of original articles from all selected journals editions between 1920 and 1965 were screened for the occurrence of 1 of the 12 keywords. A total of 26,132 original article titles were screened for the occurrence of the keywords. A total of 1815 keywords were found. Whereas *Anesthesia & Analgesia* had the highest keyword occurrence (493 citations), *Schmerz-Narkose-Anaesthesie* had the lowest (38 citations). The number of publications of the 12 keywords was significantly higher in the postwar than in the prewar period (65% and 35%, respectively; $P < .001$). Not surprisingly, the anesthesiology journals have a higher occurrence of keywords than those journals covering other specialties. The overall occurrence of keywords also showed peaks during other major conflicts, namely the Spanish Civil War (1936–1939), the Korean War (1950–1953), and the Vietnam War (1955–1975). For the first time, this study demonstrates statistically the impact of WWII on the progress of anesthesiology. It also offers an objective record of the chronology of the major advances in anesthesiology before and after the conflict. While the war arguably helped to enhance anesthesiology as a specialty, in return anesthesiology helped to heal the wounds of war. (Anesth Analg 2022;134:216–24)

GLOSSARY

COVID-19 = coronavirus disease 2019; **WWI** = World War I; **WWII** = World War II

Hitler invaded Poland on September 1, 1939. This event dragged the world into a massive conflict with disastrous political, economic, and social consequences. During the 6 years of war, death and terrible injuries were inflicted on civilians as well as on soldiers all over the world. Anesthesiology, in its infancy at that time, was suddenly called upon to rise to the challenge of treating mass casualties.

Fortunately, the historical setting fostered this substantial development. Two historical developments were of major importance in enabling anesthesiology to take center stage: the growing interest in anesthesia as a consequence of World War I (WWI); and the

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emergence of the first university departments specializing in the field during the interwar period. WWI undeniably brought a new insight into a specialty that was previously performed mainly by nurses, medical students, and, on occasion, even by the physician's chauffeur! Advances were made in the understanding of intravenous fluid therapy in shock, blood transfusions, the risk of pulmonary aspiration, the use of oxygen, and the availability of new anesthetic equipment.[1] Recognition of the importance of anesthesia as a medical specialty confirmed the necessity to organize further training.[2] This led to the second factor: the development of an academic foundation for the subject during the interwar period. In the United States, the first departments of anesthesia were created, with, among them, John Lundy at the Mayo Clinic in Rochester, Minnesota (1924); Ralph Waters at the University of Wisconsin (1927); and Henry Beecher at the Harvard Medical School in Boston (1936). In the United Kingdom, the creation of the first academic department of anesthesia was more or less decided over a round of golf, and Robert Macintosh became the first Nuffield Professor of Anesthetics at the University of Oxford (1937).[3] The interwar period also saw the emergence of the first academic journals on the subject, with *Anesthesia & Analgesia* (1922), the *British Journal of Anaesthesia* (1923), and *Anesthesiology* (1940). The American Society of Anesthesiologists was founded in 1935.[4]

In Germany, 3 universities were active in anesthesia, with Hans Killian at the University of Freiburg, Paul Sudeck and Helmuth Schmidt at the University of Hamburg, and Carl Gauss at the University of Würzburg. The first journals in German on the subject were established in 1928 by Killian and Gauss: *Der Schmerz* and *Narkose und Anaesthesie*. One year later, these 2 journals would merge into *Schmerz-Narkose-Anaesthesie*.[5,6] Enriched with this background, anesthesia was ready to rise to the challenge on the eve of the 1939–1945 hostilities.

However, the influence of World War II (WWII) on the development of anesthesiology had not yet been a major subject of study. After 2 world wars, it was difficult to defend a hypothesis that war is good for medicine. As Roger Cooter tackled the subject in 1990, he merely concluded that the relationship between medicine and war was "remarkable for the silence that surrounds it." "War," he said, "was a fusty, musty, dusty old subject."[7] But in 2001—in an impressive special article—David Waisel analyzed the role of WWII on anesthesia's growth. He reported the key factors responsible for advances as being the effect of wartime anesthesia training; the nature of combat anesthesia; and the exposure of surgeons and other physicians to the medical practice of anesthesiology.[5] Although these key factors have been identified qualitatively, the growth of the specialty owing to the war has not yet been quantified.

WWII started over 80 years ago and ended nearly a century after the first demonstration of anesthesia with ether in Boston (1846). In 1939, anesthesia found itself confronted with a world-scale demand for protocols of treatment and structured action plans for unknown emergency situations. WWII was an event of major influence on the development of anesthesiology as a medical specialty. The aim of this study is to measure and quantify the extent of anesthesia's evolution as a result of the 1939–1945 hostilities. To examine this evolution, we designed a bibliometric research study concerning the occurrence of keywords related to anesthesia in the titles of the journal articles. The analysis reveals new insights about the relationship between anesthesia and WWII.

According to Roger Cooter, "The history of medicine and war might reveal more than we have yet dared to imagine about the construction of disease entities, the structuring of medical institutions, and the daily practice of medicine as we know it. The call for research can be heard loudly."[8]

METHODS

We assessed the evolution of anesthesiology during the WWII conflict using the medical literature. To run a statistical analysis of the publication rates in anesthesia around WWII, we designed a retrospective observational bibliometric study, that is, statistical methods to analyze the content of articles, journals, books, and other publications. Therefore, 7 medical journals were selected and titles of the original articles published between 1920 and 1965 were screened for the occurrence of 12 chosen keywords.

In 1939, anesthesia was performed mainly by nonspecialized physicians, and only 2 dedicated journals existed (*Anesthesia & Analgesia* and the *British Journal of Anaesthesia*). To cover publications related to anesthesia in the medical literature at that time, the 7 selected journals contained the North American, British, and German anesthesiology literature—*Anesthesia & Analgesia* (1922–present), *British Journal of Anaesthesia* (1923–present), *Anesthesiology* (1940–present), *Schmerz-Narkose-Anaesthesie* (1929–1944)—the surgical field: *Surgery* (1937–present)—French medical practice: *La Presse Médicale* (1893–1971)—and the military domain: *The Military Surgeon*, later *Military Medicine* (1891–present). Research in *La Presse Médicale* and *Surgery* was performed in the Biomedische bibliotheek, Katholieke Universiteit Leuven, Belgium. Volumes of *The Military Surgeon*, later *Military Medicine*, and *Schmerz-Narkose-Anaesthesie* were accessed through the University of Western Ontario

in Canada. Original titles of *Anesthesia & Analgesia*, the *British Journal of Anaesthesia*, and *Anesthesiology* were screened on the online journal websites. Volumes published between 1920 and 1965 were included, thereby overlapping for the 20 years before and after WWII.

The keywords represent important advances in anesthesiology since the 1920s, namely "anesthesia," "balanced anesthesia," "barbiturates," "d-tubocurarine," "endotracheal intubation," "ether," "lidocaine," "morphine," "spinal anesthesia," "thiopental," "transfusion," and "trichloroethylene." They were chosen after a large review of the literature performed in libraries in Belgium and Canada, including literary works in English, French, Dutch, and German. The chosen keywords cover various aspects of anesthesia practice: "drugs," "techniques," "new concepts," "pain treatment," and "fluid resuscitation." "Ether" and "spinal anesthesia" were used as control keywords, considering their widespread use before WWII.

Titles of the original articles in all journal editions between 1920 and 1965 were screened for the keywords' occurrence. The only exception was "anesthesia," which was searched only in the 3 journals not dedicated to anesthesiology. The review was performed by a single trilingual observer. Data were gathered and summarized in tables using Microsoft Excel. Values were grouped in nine 5-year clusters (1920–1924, 1925–1929, 1930–1934, 1935–1939, 1940–1944, 1945–1949, 1950–1954, 1955–1959, and 1960–1965). To standardize results between the 7 selected journals, we defined a keyword impact. The keyword impact of a journal is the keywords' occurrence in article titles divided by the number of articles published, for a 5-year cluster. The keyword-impact percentage is the keyword impact multiplied by 100.

In addition, to compare the results in the field of anesthesia with the evolution of publication rates in medical literature in general, an equivalent medical bibliometric study was performed. Four medical keywords were defined accordingly ("hypertension," "pneumonia," "renal insufficiency/failure," and "tuberculosis"). In the 2 journals selected for this purpose (namely *The Lancet* and *The New England Journal of Medicine*), titles of the original articles published between 1920 and 1965 were screened for the occurrence of the 4 chosen keywords. This was researched on the online journals' websites. The keyword-impact percentage calculated on the basis of the results enables the measurement of the evolution in specialty-related publications (anesthesia versus general medicine).

Statistical Analysis

The Pearson χ^2 test was used to evaluate the association between keywords' occurrence before and after WWII. Data were divided into prewar (1920–1939) and postwar (1940–1965) periods. When performed on the journals separately, data from *Anesthesiology* (1940–present), *Schmerz-Narkose-Anaesthesie* (1929–1944), and *Surgery* (1937–present) were excluded as their publication did not cover the entire research period. All other analyses in this study included data from the 7 chosen journals.

The same χ^2 test was performed on the occurrence of the 4 medical keywords in the 2 general medical journals selected (namely, *The Lancet* and *The New England Journal of Medicine*).

Analyses were performed with SPSS version 15.0 (SPSS Inc). Results were expressed in graphs, histograms, and cross-tabulations.

RESULTS

A total of 311 journal volumes were collected. One volume and 2 issues could not be retrieved. We reviewed 26,132 original articles' titles, and 1815 keywords were found among them.

During the 1920–1965 period covered by this study, *Anesthesia & Analgesia* had the highest keywords' occurrence: 493 article titles included the citation of 1 of the 12 chosen keywords. The German journal *Schmerz-Narkose-Anaesthesie* recorded the lowest keywords' occurrence, with a total of 38 citations. The 1950–1954 cluster is the 5-year period with the highest keywords' occurrence (329 citations), while the first cluster (1920–1924) has the lowest occurrence, with only 53 citations.

When organized into 9 successive 5-year clusters and exposed by journal, the emergence of each keyword in the literature becomes apparent. Prewar clusters mainly contain the control keywords "ether" and "spinal anesthesia," sometimes joined by the keywords "morphine" and "transfusion." All other keywords make their first appearance in the 1940–1944 period (Figure 1).

By Journal

After dividing the research period into pre- (1920–1939) and postwar (1940–1965) periods, a Pearson χ^2 test was performed on keyword occurrence before and after WWII. Only those journals whose publications spanned the entire research period were included in the analysis.

The number of publications of the 12 keywords was significantly greater in the postwar than in the prewar period ($P < .001$; Table 1).

By Keyword

Individual analysis of each keyword's occurrence reveals unique patterns that can be explained by the history of each keyword (Figure 2). If divided into pre- and postwar periods, a Pearson χ^2 test performed on the keywords separately shows that the occurrence

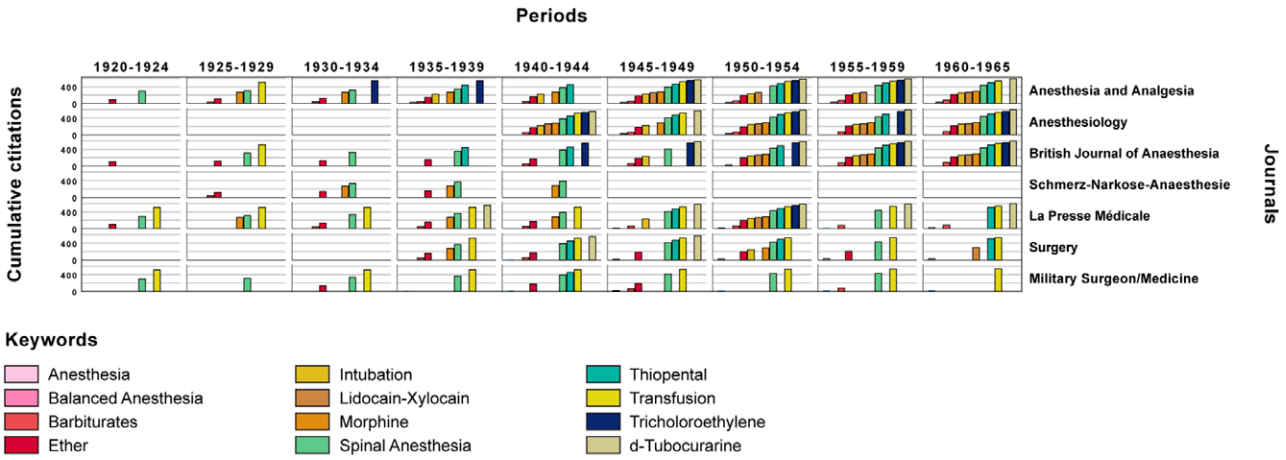

Figure 1. Journal keyword occurrence by 5-y cluster. Cumulative citation of each keyword in original article titles by the journal during the 5-y period of the cluster (keyword colors are identical to Figure 2).

Table 1. Journal Keyword Occurrence Before and After WWII

	Keywords' occurrence			
Journal	**Prewar**	**Postwar**	**Total**	**Pearson χ^2**
Anesthesia bibliometric study				
Anesthesia & Analgesia	187	306	493	
British Journal of Anaesthesia	61	192	253	
La Presse Médicale	134	203	337	
Military Surgeon/Medicine	26	56	82	
Total	408	757	1165	$P < .000$
Medical bibliometric study				
The Lancet	260	401	661	
New England Journal of Medicine	294	248	542	
Total	554	649	1203	$P = .285$

Abbreviation: WWII, World War II.

Table 2. Total Keyword Occurrence Before and After WWII

Keyword	**Prewar**	**Postwar**	**Total**	***P* value**
Anesthesia	64	152	216	.000
Balanced anesthesia	1	8	9	.047
Barbiturates	35	113	148	.000
d-Tubocurarine	1	130	131	.000
Endotracheal intubation	2	118	120	.000
Ether	127	187	314	.205
Lidocaine	0	30	30	
Morphine	12	54	66	.000
Spinal anesthesia	159	191	350	.590
Thiopental	12	193	205	.000
Transfusion	42	147	189	.000
Trichloroethylene	2	35	37	.000
Total	457	1358	1815	

Abbreviation: WWII, World War II.

of 9 of the 12 keywords was significantly greater in the postwar period ("anesthesia" [$P < .001$], "balanced anesthesia" [$P = .047$], "barbiturates" [$P < .001$], "d-tubocurarine" [$P < .001$], "endotracheal intubation" [$P < .001$], "morphine" [$P < .001$], "thiopental" [$P < .001$], "transfusion" [$P < .001$], "trichloroethylene" [$P < .001$]; Table 2).

"Ether" ($P < .21$) and "spinal anesthesia" ($P < .59$), the 2 control keywords in this study, have a P value >.05, meaning there is no difference in their publication rate before and after the war. The test could not be performed on the keyword "lidocaine" because there was no occurrence of this keyword in the prewar period, as it was discovered in the 1940s.

By Medical Specialty

The keyword-impact percentage (keywords' occurrence in article titles/number of articles published by the journal × 100) enables standardization of data and allows comparison between the journals. Consequently, medical specialties can also be compared between them (subject to the journals selected in this study). The anesthesiology journals have, as expected, a higher keyword-impact percentage than the journals covering other specialties. The keywords' occurrence in *Surgery* declined in the postwar period. *Military Surgeon/Medicine* has the lowest keyword-impact percentage (Figure 3).

By World Conflict

Overall keywords' occurrence observed year by year over the entire research period shows increases in anesthesia-related publications during other conflicts (according to the keywords selected in this study): the Spanish Civil War (1936–1939), the Korean War (1950–1953), and the Vietnam War (1955–1975; Figure 4).

Medical Bibliometric Study

In the journals of the general medical literature (*The Lancet* and *The New England Journal of Medicine*), 1203 keywords were found among the 32,487 original articles' titles screened. Interestingly, the distribution of the keywords over the 1920–1965 research period differs markedly from the anesthesia bibliometric study. The same Pearson χ^2 test was performed on the "medical keywords" occurrence before and after WWII,

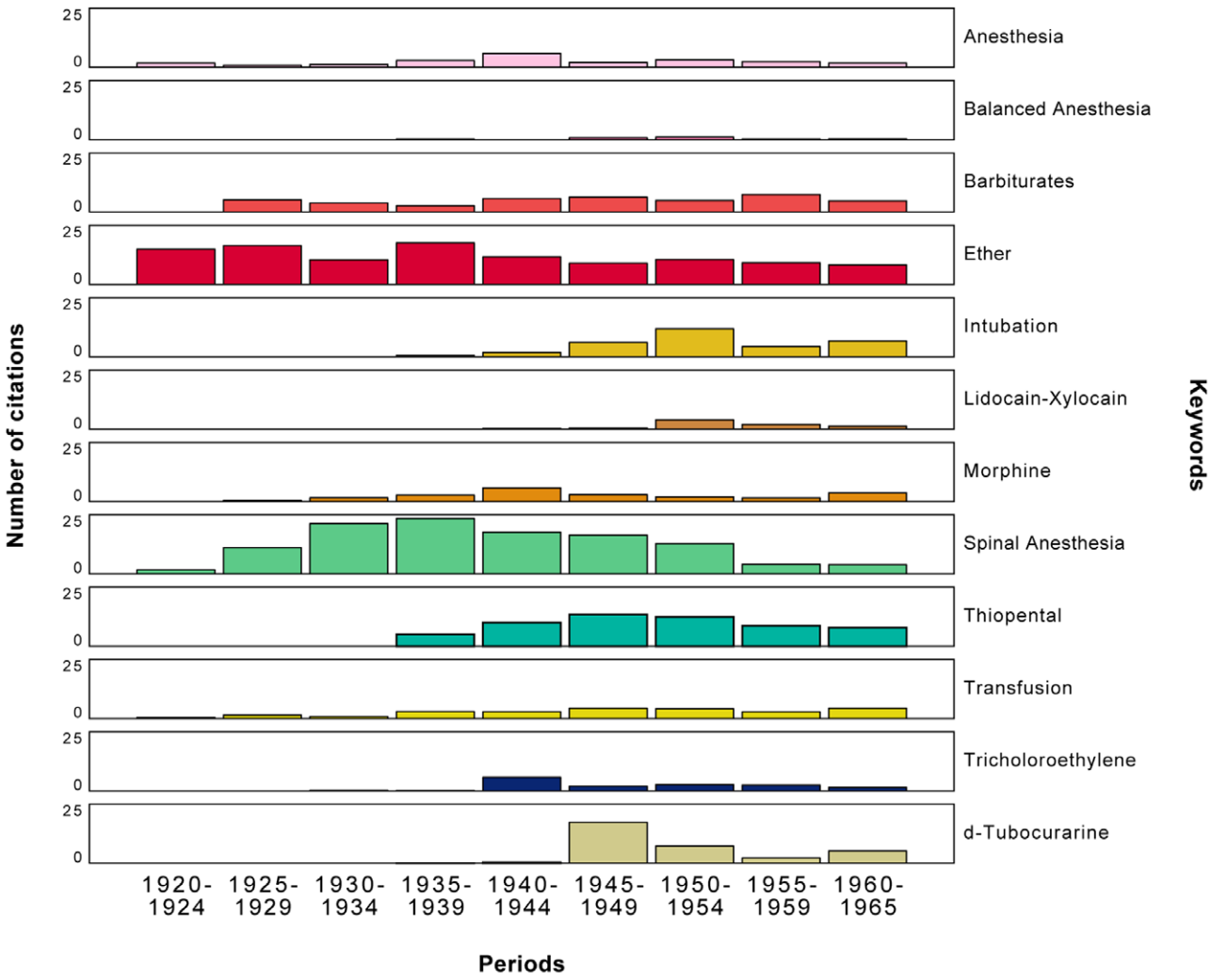

Figure 2. Individual keyword occurrence by 5-y cluster. Number of citations of each keyword in original article titles of all journals, during the 5-y period of the cluster.

with a $P = .285$ meaning there is no difference in their publication rate before and after the war (Table 1).

To compare the evolution of publications in anesthesia with the general medical literature, we analyzed the evolution of the keyword-impact percentage from the 1935–1939 cluster with the 1945–1949 cluster, for both domains. Publications related to anesthesia increased by 30.13% compared to a 1.49% increase for publications in the general medical literature.

DISCUSSION

Medical specialties experience incredible growth when stressed by acute conditions from the outside. WWII had a major influence on the development of anesthesiology as a medical specialty. In the second half of the 20th century, there was a significant increase ($P < .001$) in medical publications concerning anesthesiology, when compared with the prewar period (Table 1). All 12 of the chosen keywords appear in journal article' titles after the start of WWII in 1939 (Figure 1). The keywords are representative of major advances in anesthesiology during WWII. Their publication signifies that they are the subject of discussion among physicians sharing new knowledge. Figure 1 reflects this evolution very clearly, with the onset of each keyword's histogram in the 1940–1944 cluster. While the 1950–1954 cluster is the period having the highest keyword occurrence, this can be explained by a postwar resumption of scientific publication and international sharing of knowledge.

In this study, different types of journals were screened, including those pertaining to general practice, surgery, military medicine, and anesthesiology. It is obvious that those devoted to anesthesia have the highest keyword occurrence. Analysis of the keyword-impact percentage reveals where new information about anesthesia has been published and allows comparison between journals (Figure 3). At the beginning of the 20th century, many articles regarding anesthesia were published in surgical journals or those

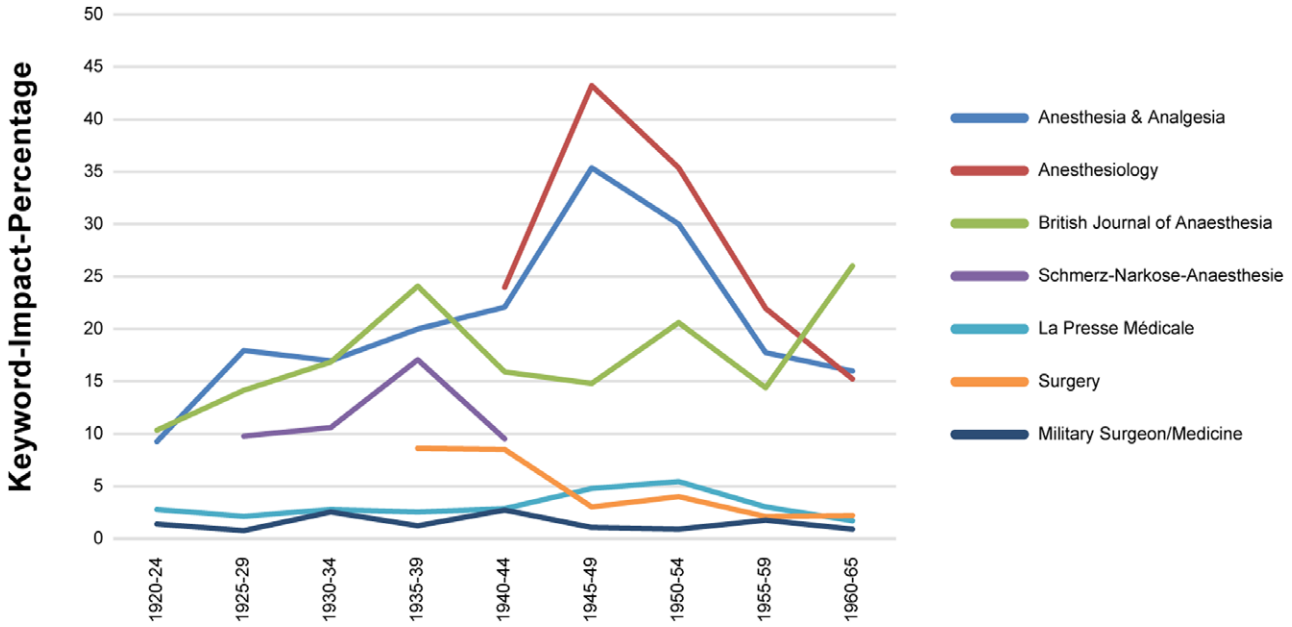

Figure 3. Keyword-impact percentage, by journal. Evolution of keyword-impact percentage for each journal, by 5-y cluster. The keyword-impact percentage allows standardization of data and comparison of publication rates between journals.

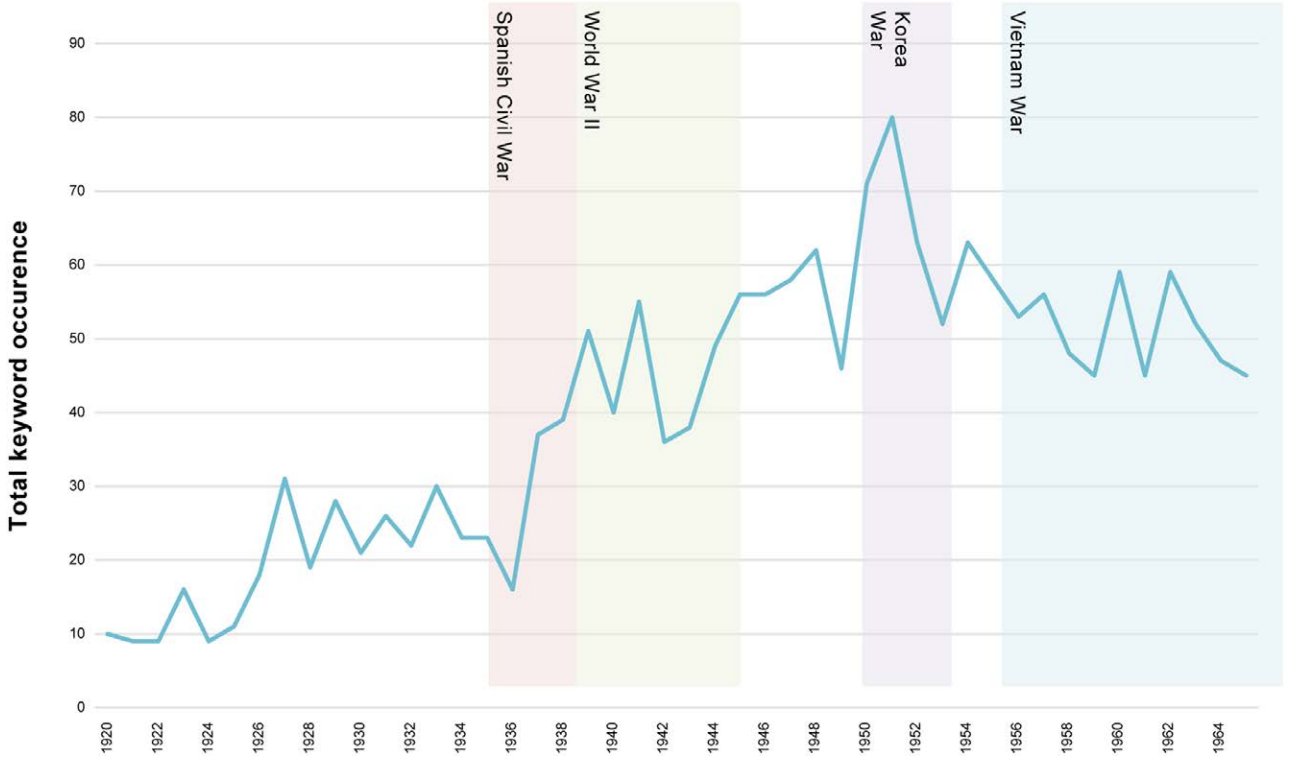

Figure 4. Keyword occurrence by world conflict. Citation of all keywords in original article titles of all journals.

concerning general practice. With the ongoing war and anesthesia being delivered and reported by the army, we thought the latest news would reach a journal like *Military Surgeon* before others. But events like the many deaths due to the administration of thiopental on patients suffering hemorrhagic shock at Pearl Harbor (1942) were not published in *Military Surgeon* but instead published in anesthesiology journals.[9]

An exception to the rule that anesthesiology journals have the most articles about anesthesia is the German journal *Schmerz-Narkose-Anaesthesie*, which published few articles on anesthesia. The explanation lies in the history of the journal. In 1928, at a meeting in Minnesota, Francis McMechan, leader of North American anesthesia, praised the editors of the German journal for their work. This event is

representative of strong international academic relationships during the interwar period. But as the editorial board consisted of many Jewish physicians, they suffered from anti-Jewish legislation after Hitler's power grab in January 1933. Boycotted, *Schmerz-Narkose-Anaesthesie* stopped being published in 1944, sadly clarifying this trend.[10]

Another fact about the journals' editions is the marked decrease in medical publications during WWII. Even if expected, the usually heavy volumes of *La Presse Médicale* suddenly became lightweight (Figure 4). Although paper shortage and rationing during the war might have reduced publication rates, censorship on new drugs and techniques probably contributed to this reduction.[11] This drop in publications may also be associated with many doctors being enlisted at the time, and the medical profession being placed on a war footing.

A closer look at the particular frequency of each keyword's occurrence over the years can be explained by their own history. There is no other study to compare these results with, although history books can clarify this study's findings. The following is a short description of each keyword's trend.

"Ether" and "spinal anesthesia," used as control keywords, were the most frequently cited keywords (314 and 350, respectively), and their occurrence never dropped (Table 2). Ether was destined to be abandoned but remained the anesthetic of reference—the control drug to which new drugs' properties were compared—explaining its stable citation rate over the years (Figure 2). During WWI, spinal anesthesia was known to be effective but also feared because of its high rate of complications. Back then, when performed on soldiers in hypovolemic shock, for example, it had a high incidence of cardiovascular collapse. Thanks to better knowledge of cardiovascular physiology, however, its use would eventually become safer and thus more widespread.[1]

The search for the ideal anesthetic continued and new drugs were rapidly introduced to medical practice. Trichloroethylene was one of them. It had the advantage of being cheap, readily available, and nonflammable, which constituted a great advantage when used on the battlefield. But its use in closed-circuit apparatus was abandoned in 1944 when toxic formation of dichloracetylene was identified, thereby explaining the low number of citations (37) in this study (Figure 2).[12,13] Another drug that had a bad reputation because of poor pharmacological knowledge was thiopental, a quick-acting barbiturate. Its misuse regarding hypovolemic shock was responsible for many deaths at Pearl Harbor, though numbers were exaggerated.[14,15] Nevertheless, anesthesiologists appropriated the drug and became keepers of its safe use, emphasizing once again that this was a physician's specialty.[5] With an occurrence of 205, thiopental has a high publication rate, especially during the 1945–1949 and 1950–1954 clusters (Figure 2).

The technique of endotracheal intubation experienced a great evolution during WWII. Although it was described in the early 1920s, this keyword has only 2 citations in the prewar period (Table 2). While Ivan Magill is well known by anesthesiologists for his forceps, his major contribution to the specialty is his description of blind endotracheal intubation with Stanley Rowbotham in 1921.[16] After WWI, there was an urgent need for this new technique to allow surgery on the "broken faces." But WWII resulted in the widespread use of endotracheal intubation, when battlefield casualties suffering from chest, head, and neck injuries required young anesthetists to master the technique to avoid airway obstruction. The endotracheal intubation postwar occurrence rose accordingly, by 98.3% (Table 2). This major advance was possible thanks to the development of new laryngoscope blades and endotracheal tubes, and the introduction of muscle relaxation.[17,18] From its use in deadly poisoned arrows by South American Indians in the 16th century to the safe administration during anesthesia in the 1940s, d-tubocurarine has come a long way.[19] In 1942, Harold Griffith and his colleagues reported the successful use of intocostrin during anesthesia in a paper that would transform the specialty. A year later, the drug would be flown across the ocean with a North American bomber squadron to be introduced in the United Kingdom. In this study, the 1945–1949 cluster has the highest occurrence for d-tubocurarine, indicating the importance of the drug for anesthesia practices (Figure 2). Muscle relaxants transformed anesthesia practices by reducing the need for deep anesthesia, facilitating endotracheal intubation, and providing excellent operating conditions for the surgeon.[20]

Nevertheless, the first goal of anesthesia has always been pain relief.[21] Therefore, morphine has played a key role. WWI had already seen morphine in "hypo units" that a soldier could administer to oneself with one hand. With pressure from the US Army, these "hypo units" evolved into improved syrettes by WWII, and 75 million of them were produced.[22] Side effects of morphine were identified and after administration, each syrette had to be attached to the soldier's chest to prevent overdose. Knowing this, it is surprising that morphine has a total of only 66 citations over the research period (Table 2).

Lidocaine, on the other hand, was first synthetized in Sweden in 1943 and was of great interest because of its low toxicity, quick onset, and longer duration compared to ester local anesthetics.[23] Even though the present study shows an increase in the publications related to the subject, Sweden remained neutral during WWII and so the chemist Nils Löfgren was

perhaps not influenced by the ongoing conflict during his research.

Pain control was of importance in the treatment of shock, and the understanding of these 2 elements improved during the war. Advances in fluid resuscitation and blood transfusion saved many lives that would otherwise have been lost during WWI.[1] This keyword has a steady occurrence over the years, which reflects the long road to safe use and guidelines on blood transfusion (Figure 2). Once the problems of coagulation (Hustin, 1900) and infection (Pasteur & Koch, 19th century) were resolved, and the ABO (Landsteiner, 1900) and Rhesus (Landsteiner & Wiener, 1940) blood group system established, blood transfusion could be performed on a large scale. While Europe started bleeding under the Nazi boot, blood was readily stored in the first blood banks.[24]

Together, these drugs and techniques introduced anesthesia into a new era. By describing balanced anesthesia in 1929, John Lundy laid the foundation for modern anesthesia. In his early version, balanced anesthesia involved the association of premedication, light general anesthesia, and regional anesthesia to reduce complications. Since the war, the concept has become the basis for today's practice: hypnosis, analgesia, oxygenation, removal of CO_2, muscle relaxation, and circulatory/acid-base/electrolyte equilibrium.[25] Despite its indisputable importance, balanced anesthesia has only 9 citations in this study.

Training for wartime anesthesiology made a major contribution for the growth of the specialty. An example in the United States anesthesia is the training of the "90-day wonders," organized by the Subcommittee on Anesthesia of the National Research Council.[26] These intense, short courses enabled qualified young anesthetists to be sent to the frontline. Confronted with the problems of wartime practice on the field, they sent back letters to the course instructors to share their experiences and the difficulties they were facing. The letters came from Australia, Belgium, Canada, China, England, France, Germany, India, Italy, North Africa, New Guinea, Persia, the Philippines, the South Pacific, Sicily, Tunisia, and the United States, thereby reflecting the extent of a world war. John Lundy, at the Mayo Clinic, Minnesota, then published the letters in the *Anlet*, a newsletter he created to distribute to the colleges engaged in the military programs.[27] The organization of such short training programs was of critical importance to the spread and standardization of anesthesia practices and showed the influence of anesthesia in modern medicine.

Outside the field of anesthesiology, the pressure of war also worked as a catalyst for other research subjects. A good example was the secret large-scale production of penicillin, which the Allied Forces used to their advantage.[28] And, it is still not known whether it was Allied penicillin, captured or inadvertently supplied, that saved Hitler's life after the failed assassination attempt in July 1944.[29]

These 12 chosen keywords were presumed to be representative of the evolution in anesthesia during WWII (except for "ether" and "spinal anesthesia," the control keywords). Nevertheless, the peak of keyword citations occurs in the early 1950s (Figure 4). This may be due to the delay in international scientific sharing of knowledge acquired during the war, but it also occurs in the midst of the Korean War. Further studies should identify which part of evolution in the field of anesthesiology is attributable to the next world conflicts.

Limitation/Bias

The choice of the keywords used in this bibliometric study constitutes its major potential bias because the choice is far from exhaustive. This study is based mainly on the English-language medical literature, although attempts were made to cover German literature as well. The situation elsewhere, such as in Japan, might have been different. There may also have been progress during the conflict that was not published but shared in another way among professionals.

CONCLUSIONS

Anesthesiology emerged mature from WWII. It had attracted much interest and praise and was recognized as a medical specialty in its own right. The proof is the postwar increase in societies, training programs, and both national and international conferences. In the United States, membership of the American Society of Anesthesiologists quadrupled from 1940 to 1960, and cases performed by physician anesthetists more than tripled from 1940 to 1962.[5] Medicine and history, especially conflict history, can no longer be regarded as 2 independent disciplines, but as closely correlated subjects, whose development is intrinsically intertwined.

Despite its limits, we hope that this bibliometric study could be used in the future as a model to study the influence of major worldwide events on the progress of the different specialties of human medicine. The current coronavirus disease 2019 (COVID-19) pandemic demonstrates once again how an urgent need for medicine exerts pressure on the academic profession to come up with solutions. We believe analysis of past events can bring surprising insights into our specialties and help us to conceive how we will regard tomorrow's medical practices.

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DISCLOSURES

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Contribution: This author helped with data analysis and interpretation, and revising the paper.
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Name: Raymond Reding, PhD.
Contribution: This author helped with study's conception and design, and revising the paper.
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