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Original Research

The 100 most cited manuscripts in emergency abdominal surgery: A bibliometric analysis

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HIGHLIGHTS

- A Bibliometric analysis was performed, establishing the most influential publications in emergency abdominal surgery.
- Vascular surgery, risk assessment and gastrointestinal surgery are the topics most commonly cited.
- Emergency surgery for cancer and intra-abdominal sepsis are relatively poorly represented.

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ABSTRACT

Background: The number of citations a scientific article receives provides a good indication of its impact within any given field. This bibliometric analysis aimed to identify the 100 most cited articles in Emergency Abdominal Surgery (EAS), to highlight key areas of interest and identify those that have most significantly shaped contemporary clinical practice in this newly evolving surgical specialty. This is of increasing relevance as concerns grow regarding the variable and suboptimal outcomes in Emergency General Surgery.

Materials and methods: The Thomson Reuters Web of Science database was used to search using the terms [Emergency AND Abdom* AND Surg*] to identify all English language, full manuscripts. Results were ranked according to citation number. The top 100 articles were further analysed by subject, author, journal, year of publication, institution, and country of origin.

Results: The median (range) citation number of the top 100 out of 7433 eligible papers was 131 (1569-97). The most cited paper (by Goldman et al., Massachusetts General Hospital, New England Journal of Medicine; 1569 citations) focused on cardiac risk stratification in non-cardiac surgery. The Journal of Trauma, Injury, Infection and Critical Care published the most papers and received most citations (n = 19; 2954 citations. The majority of papers were published by centres in the USA (n = 52; 9422 citations), followed by the UK (n = 13; 1816 citations). The most common topics of publication concerned abdominal aneurysm management (n = 26) and emergency gastrointestinal surgery (n = 26).

Conclusion: Vascular surgery, risk assessment and gastrointestinal surgery were the areas of focus for 59% of the contemporary most cited emergency abdominal surgery manuscripts. By providing the most influential references this work serves as a guide to what makes a citable emergency surgery paper.

1. Introduction

Concern has been growing regarding the variable and suboptimal outcomes in Emergency General Surgery (EGS) across the United Kingdom, and in particular the high mortality associated with emergency laparotomy [1]. Consequently there has been an initiative to recognise EGS as a specialty in its own right, and to

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develop resources for dedicated research and postgraduate surgical training programmes [2,3].

The establishment of a citation rank list identifies published work that has the greatest intellectual influence [4]. A citation is received when a publication is referenced by another peer-reviewed article. Work that has the greatest impact on the scientific community is therefore likely to be cited many times. The method of citation analysis involves ranking and evaluating an article or journal based on the number of citations it receives. In addition to determining the most frequently cited articles, this analysis is also used to rank journals in terms of their impact upon the scientific and clinical community [4]. Many medical and surgical specialties have utilised the citation rank analysis to identify the most influential papers in their field, including; trauma and orthopaedic surgery [5], plastic surgery [6], general surgery [7], and oncology [8]. To date, no study has been undertaken to determine the most influential papers in the emerging field of emergency abdominal surgery (EAS). 'This bibliometric analysis aimed to determine research themes that have been most influential in developing understanding and management of EAS pathology.'

2. Materials and methods

The Thompson Reuters Web of Science citation indexing database was searched using the terms [Emergency AND Abdom* AND Surg*]. 'To ensure that a thorough search was performed, the aforementioned search terms were agreed after independent trial searches by two reviewers. The final Web of Science database interrogation was performed jointly by two researchers. The search was limited to English language, full manuscripts or abstracts, and results were ranked by citation number using the method first demonstrated by Paladugu and colleagues [7]. The 100 articles with the most citations were further analysed by subject, author, journal, year of publication, institution, and country of origin. A potential bias for this type of study is that older manuscripts have more time to accrue citations. Therefore a citation rate variable was created by divided the number of citations by the number of years since publication.

Exclusion criteria were articles in languages other than English and those in which the main focus of study was something other than EAS. Articles accruing identical numbers of citations were ranked their respective citation rates.

3. Results

The Web of Science database search returned 17,433 full manuscript, English language papers. Table 1 lists the 100 most cited of these papers [9–108]. All were full manuscripts, as no published abstracts were identified in the top 100 publications. The most cited article by Goldman et al. investigating cardiac risk in non-cardiac surgery was published in the New England Journal of Medicine in 1977 and cited 1569 times [9]. The oldest manuscripts featured in the top 100, both published in 1975, were by Stone et al. investigating intra-peritoneal bacteria cited 180 times [32], and Hicks et al. investigating survival improvement following aortic-aneurysm resection cited 158 times [48]. The most recent manuscript by Shaw et al. was a comparative study of mortality rates between different intravenous resuscitation fluids published in the Annals of Surgery in 2012 and cited 125 times [66].

The 100 most influential papers were across 27 journals, with the number of manuscripts per journal ranging from 1 to 19 (Table 2). The Journal of Trauma-Injury Infection and Critical Care published the most papers and also gained the most citations (n = 19; 2954 citations). The journal with the highest impact factor (55.87) was The New England Journal of Medicine, which was the journal of publication of the most cited article [9].

The country with the greatest number of publications in the top 100 was the United States of America (USA; n = 52; 9422 citations) followed by the United Kingdom (UK; n = 13; 1929 citations). The Massachusetts General Hospital had the most citations with 1569, whereas the institution with the largest number of manuscripts in the top 100 was Baylor College of Medicine, Houston, with 4 articles. No first author had more than 2 manuscripts in the top 100 (Arozullah AM [14,21], Bode PJ [81,98], Feliciano DV [40,104], Stone HH [13,32]. Similarly, only three senior authors had more than one manuscript and none more than two (Herfarth C [54,72], Trentz O [31,43], Tscherne H [33,45]).

The citation rate for the top 10 manuscripts ranged from 40 for Goldman et al. (Multifactorial index of cardiac risk in non-cardiac surgical procedures) [9] to 17 for Sauerland et al. (Laparoscopy for abdominal emergencies - evidence-based guidelines of the European Association for Endoscopic Surgery) (Table 3) [36]. The USA had the most papers in the top 10 citation rate with 4, the UK,

Table 1
The Top 100 cited manuscripts in Emergency Abdominal Surgery.

Rank	Citations	First author	Rank	Citations	First author
1	1569	Goldman L [9]	51	131	Torsello GB [59]
2	364	Stoppa RE [10]	52	131	Umpleby HC [60]
3	353	Alvarado A [11]	53	130	Hollier LH [61]
4	252	Voyles CR [12]	54	129	Temple CL [62]
5	247	Stone HH [13]	55	128	Shackford SR [63]
6	246	Arozullah AM [14]	56	128	Leung JWC [64]
7	244	Balogh Z [15]	57	127	Leitman IM [65]
8	235	Cruz DN [16]	58	126	Shaw AD [66]
9	233	Scalea TM [17]	59	126	Kieffer E [67]
10	218	Rozycki GS [18]	60	123	Schiedler MG [68]
11	212	Johansen K [19]	61	122	Canet J [69]
12	206	Gao F [20]	62	120	Mehta M [70]
13	205	Arozullah AM [21]	63	120	Raeburn CD [71]
14	200	Smetana GW [22]	64	119	Post S [72]
15	193	Malone AJ [23]	65	119	Gomican SP [73]
16	191	Bengtsson H [24]	66	117	Sato N [74]
17	189	Richardson JW [25]	67	116	Hallin A [75]
18	188	Lane MJ [26]	68	115	Mirvis SE [76]
19	188	Moore EE [27]	69	114	Tack D [77]
20	188	Mucha P [28]	70	113	Coleman MG [78]
21	186	Krukowski ZH [29]	71	113	Hoskin PJ [79]
22	183	Kingsnorth A [30]	72	112	Castleden WM [80]
23	181	Ertel W [31]	73	111	Bode PJ [81]
24	180	Stone HH [32]	74	108	Vieweg J [82]
25	177	Hoffmann R [33]	75	108	Pederson T [83]
26	177	Ellis H [34]	76	108	Shimazu S [84]
27	174	Limet R [35]	77	107	Hertzer NR [85]
28	173	Sauerland S [36]	78	106	Claridge JA [86]
29	173	Johnson JW [37]	79	106	Attard AR [87]
30	173	Yusuf SW [38]	80	105	Nelson R [88]
31	172	Ingoldby CJH [39]	81	104	Van Ruler O [89]
32	170	Feliciano DV [40]	82	104	Tiwari A [90]
33	169	Djokovic JL [41]	83	104	Bjorck M [91]
34	167	Tso P [42]	84	103	Alsac JM [92]
35	166	Rothlin MA [43]	85	103	Smothers L [93]
36	166	Fowkes FGR [44]	86	103	Dolich MO [94]
37	161	Regel G [45]	87	103	Ernst GB [95]
38	160	Pacelli F [46]	88	102	Kaplan GG [96]
39	160	Kashuk JL [47]	89	102	Peppelenbosch N [97]
40	158	Hicks GL [48]	90	102	Bode PJ [98]
41	157	Clarke JR [49]	91	102	Chassin JL [99]
42	153	Kortbeek JB [50]	92	101	Fuks D [100]
43	151	Liu M [51]	93	101	Oldham KT [101]
44	150	Sugrue M [52]	94	99	Trowbridge RL [102]
45	147	Gloviczki P [53]	95	99	Irvin TT [103]
46	143	Runkel NS [54]	96	99	Feliciano DV [104]
47	140	Kimura A [55]	97	99	Lawrie GM [105]
48	134	Crawford JL [56]	98	98	Branney SW [106]
49	133	Kurtz RJ [57]	99	97	Moore R [107]
50	131	Schochl H [58]	100	97	Berci G [108]

Table 2
Journals with the top 100 cited Emergency Abdominal Surgery manuscripts.

Journal Title	Impact factor as of 2015	Number of manuscripts in the Top 100	Number of citations
ACTA anaesthesiology Scandinavica	2.355	1	108
American Journal of Roentgenology	2.731	3	409
American journal of surgery	2.291	4	506
Anesthesiology	5.879	1	122
Annals of emergency medicine	4.695	2	472
Annals of Internal Medicine	17.810	2	446
Annals of Surgery	8.327	12	1918
Archives of Surgery	4.926	5	679
British Journal of Surgery	5.542	9	1202
British Medical Journal	17.445	2	272
Critical Care	4.476	3	518
Diseases of the colon and rectum	3.749	3	347
Drugs	4.343	1	113
European journal of vascular and endovascular surgery	2.490	2	219
Gastroenterology	16.716	1	102
Journal of the American Medical Association	35.289	4	607
Journal of Trauma-Injury infection and critical care	2.736	19	2954
Journal of Urology	4.360	1	108
Journal of Vascular Surgery	3.021	13	1860
Lancet	45.217	3	484
New England Journal of medicine	55.873	1	1569
Radiology	6.867	2	303
Surgery	3.380	3	303
Surgical clinics of north America	1.879	1	188
Surgical endoscopy and other interventional techniques	3.256	1	173
World Journal of Surgery	2.642	1	364

Table 3
Top 10 cited Emergency Abdominal Surgery manuscripts according to citation rate.

Rank	Citation Rate	First Author	Senior Author	Title	Institution	Country
1	40	Goldman L	Slater EE	Multifactorial index of cardiac risk in non-cardiac surgical procedures	Massachusetts General Hospital	USA
2	34	Cruz DN	Ronco C	Early Use of Polymyxin B Hemoperfusion in Abdominal Septic Shock The EUPHAS Randomized Controlled Trial	St Bortolo Hospital, Vincenza	Italy
3	32	Shaw AD	Kellum JA	Major Complications, Mortality, and Resource Utilization After Open Abdominal Surgery0.9% Saline Compared to Plasma-Lyte	Duke University	USA
4	26	Schochl H	Solomon C	Transfusion in trauma: thromboelastometry-guided coagulation factor concentrate-based therapy versus standard fresh frozen plasma-based therapy	Salzburger Landeskliniken SALK	Austria
5	20	Smetana GW	Cornell JE	Preoperative pulmonary risk stratification for non cardiothoracic surgery: Systematic review for the American College of Physicians	Harvard University	USA
6	20	Canet J	Sanchis J	Prediction of Postoperative Pulmonary Complications in a Population-based Surgical Cohort	University autonoma Barcelona	Spain
7	19	Balogh Z	Moore FA	Both primary and secondary abdominal compartment syndrome can be predicted early and are harbingers of multiple organ failure	University of Texas	USA
8	19	Gao F	Fox S	The impact of compliance with 6-hour and 24-hour sepsis bundles on hospital mortality in patients with severe sepsis: a prospective observational study	Birmingham Heartlands Hospital	UK
9	19	Kortbeek JB	Winter R	Advanced Trauma Life Support, 8th edition, the evidence for change	Foothills Medical centre	Canada
10	17	Sauerland S	Neugebauer EAM	Laparoscopy for abdominal emergencies - Evidence-based guidelines of the European Association for Endoscopic Surgery	Univ Witten Herdecke	Germany

*Citation rate was calculated by dividing the number of citations by the number of years since the publication of the manuscript.

Canada, Italy, Austria, Spain and Germany each had 1.

The number of manuscripts pertaining to each of the main topic areas is given in Fig. 1. Vascular surgery and gastro-intestinal (GI) surgery were the most widely-studied specialties, with 26 manuscripts apiece in the top 100, followed by trauma surgery, with 14 articles. 13 manuscripts examined the use of radiological techniques in emergency surgery, whereas 7 papers were related to the critical care of emergency surgical patients. Similarly, 7 manuscripts were studies of risk evaluation and stratification. Five papers were dedicated to microbiology and 2 to analgesia.

4. Discussion

This bibliometric analysis is the first of its kind to identify the authors and themes that have had the greatest impact within the emerging specialty of EGS. Several different pathological conditions and surgical interventions are encompassed by this diverse field, as illustrated by each of the top three manuscripts pertaining to a different subject area. The most cited paper was by Goldman et al. [9], (1569 citations), published in the New England Journal of Medicine, and focused on the identification of risk factors for cardiac complications following major non-cardiac surgery. The authors generate a simple point score that can be used by clinicians to stratify patients into various risk groups. The concept of risk prediction and stratification in surgery has been extensively studied and is the focus of other articles within the top 100 [14,21,22,109]. The second most cited paper by Stoppa [10], (364 citations), published in the World Journal of Surgery (impact factor 2.642), reported an overview of the general features, diagnostic and technical consequences of hernia repair in both the elective and emergency

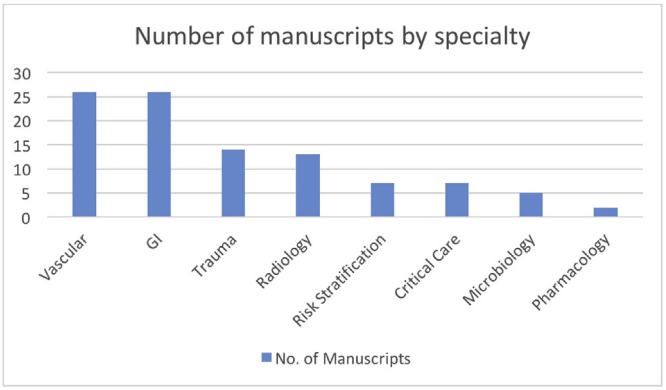

Fig. 1. Number of manuscripts relating to each surgical or medical specialty.

setting. The third most cited manuscript was by Alvorado et al. [11], (353 citations), in Annals of Emergency Medicine (impact factor 4.695), which was an observational cohort study related to the clinical and biochemical characteristics of patients presenting with abdominal pain in order to establish a scoring system to guide accurate diagnosis of acute appendicitis.

There was a significant discrepancy between the citation number of the most cited paper (1569) and all others thereafter (364–97), with an overall median citation number of 131. This trend is not seen in other published bibliometric analyses and may reflect the relevance of the topic of risk stratification to other, non-emergency surgical disciplines; thus broadening the scope of its influence. Furthermore, the citation numbers of the most influential articles in emergency abdominal surgery are significantly lower than those of other surgical specialties. For example, the three most influential papers in the field of gastric cancer identified in the recently published bibliometric analysis by Powell et al., were cited 2893, 2002, 1697 times respectively, with a median citation number of 417 [110]. The same is true in orthopaedic surgery, with the three most influential articles identified by Kelly et al. having total citation numbers of 1786, 1146, and 1088 respectively, with a median citation number of 451 [5]. This pattern, which is also seen in other non-surgical specialties [8,111], may demonstrate a relatively low level of research activity within emergency general surgery in comparison to more established specialties. It may also reflect relatively limited academic funding within this emerging field, as well as the challenges associated with conducting high quality clinical trials in an emergency surgical setting. Only 14 publications featured within the 100 most cited were randomized controlled trials. Arguably, this is may be due to the unscheduled nature of such clinical practice and emergency surgery, which is associated with formidable logistical challenges related to clinical trial intervention. Consequently, much of the evidence gathered regarding trauma and emergency surgery is from retrospective or cohort studies, in keeping with the results of this bibliometric analysis.

Analysis of the themes represented within the top 100 articles demonstrates a significant number that relate to the assessment and management of patients presenting with vascular disease, most commonly ruptured or leaking abdominal aortic aneurysms. This may reflect the rapid developments observed in the management of vascular emergencies over the past 30 years [112], with 7 publications focusing on interventional vascular procedures such as endovascular repair of abdominal aortic aneurysms [39,59,70,92,97,107]. Emergency GI surgery was the theme of 30 publications, of which 8 focused on intra-abdominal sepsis. This low number is surprising given the growing body of sepsis research among other disciplines [113], combined with the fact that mortality from intra-abdominal infections remains high despite improvements in diagnosis and antimicrobial treatment [114]. Three publications related to GI cancer [54,60,93], 16 related to abdominal trauma; 6 of which focused specifically on blunt injury and 1 penetrating trauma.

Influential publications are more likely to be cited by the scientific community and these citations form the basis of the impact factor. The impact factor of a journal quantifies the average citations of the manuscripts published within the journal during a specific period. Therefore, journals with a higher impact factor are recognised as being of a higher quality and more likely to contain influential publications. The median impact factor of manuscripts identified in this study was 4.418, with 63% published in journals with an impact factor of 5 or less. Furthermore, journals with very high impact factors (55.8–16.7); New England Journal of Medicine, Lancet, Journal of the American Medical Association, Annals of Internal Medicine, British Medical Journal and Gastroenterology represent only 13% of all publications in the top 100. Interestingly, impact factor was not representative of ranking. For example the article by Trowbridge et al. in the Journal of the American Medical Association (Impact factor 35.289) ranked 94th with 99 citations [102].

The correlation between citation number and influence is a topic that may provide an area of further research. It would be of value to establish whether these publications have been in any way integrated into modern emergency general surgery training programs and curricula.

'The results of this study are potentially limited by the presence of several forms of bias. In particular, certain articles may receive multiple citations as a consequence of institutional, self-citation or language bias. The high rate of USA publications has been mirrored in other citation rate analyses such as that by Powell et al. [110,115] and Mathews et al. [116]. Institutions in the USA may preferentially cite 'local research' explaining the high number of US publications. Alternatively, this may be due to the research culture in US medical training, which encourages physicians to integrate research with their clinical practice. This effect may have been amplified by limiting the results to English language publications. Moreover, the oldest articles have greater potential for citation due to the relative length of time they have been in the public domain, rather than representing a true measure of research impact. To control for this the number of citations were divided by the number of years since publication to give a citation rate (Table 3). Despite these attempts, lead-time for the publication of citing articles may result in more recent articles being underrepresented in this study. A further limitation is the inclusion of only first and senior authors and the institution of the first author. It is possible that several first authors will have co-authored other papers in the top 100 and are therefore under-represented in the current study format.

5. Conclusions

The most highly cited manuscripts in emergency abdominal surgery describe a wide range of topics and focus as much on vascular associated risk stratification and aneurysm management as they do on emergency gastrointestinal surgery. Similarly, emergency surgery for cancer and intra-abdominal sepsis were relatively poorly represented when related to their clinical frequency of presentation and consequent significant clinical burden. Despite its high contemporary profile, EGS appears to remain a relatively Cinderella subspecialty when viewed from the bibliometric perspective. Nevertheless, EGS is an emerging specialty and this work provides the most influential references serving as a guide as to what makes a citable emergency surgery paper.

Ethics approval and consent to participate

Ethical approval was not required for bibliometric analysis.

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Author contribution

Thomas Ellul – Data collection, analysis and writing. Nicholas Bullock - Data collection, analysis and writing. Tarig Abdelrahman - Data analysis and writing. Arfon GMT Powell – Study design, data analysis and writing. Jolene Witherspoon - Data analysis and writing. Wyn G Lewis - Study design, data analysis and writing.

Competing interests

The authors declare that they have no competing interests.

Guarantor

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Availability of data and material

All data generated during this study are included in this published article.

Abbreviations

EGS	Emergency General Surgery
EAS	Emergency Abdominal Surgery
GI	Gastrointestinal
UK	United Kingdom
USA	United States of America

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