

The 100 Most-Cited Articles in Visceral Surgery: A Systematic Review

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Key Words

Bibliometric analysis · Citation classics · Most-cited articles · Visceral surgery

Abstract

Background: Even though citation analysis has several limitations, it is a commonly used tool to determine the impact of scientific articles in different research fields. **Objective:** The study aims to identify and systematically review the 100 most cited articles in the field of visceral surgery focusing on papers that modified therapeutic concepts and influenced the surgeons' decision making. **Methods:** The 100 most cited clinical articles in visceral surgery were identified using Journal Citation Reports and Science Citation Index Expanded of the Web of Science (Thomson Reuters, Philadelphia, Pa., USA). Data for characterization of the articles were determined: Number of citations, research topic, journal, publication time, authorship, country of origin, type of article and level of evidence if reasonable. **Results:** The 100 most cited articles were published in 17 journals; 72 articles were found in the 3 journals: New England Journal of Medicine (38), Annals of Surgery (21) and Lancet (13). The oldest article was published in 1908 in Annals of Surgery (ranked 76th) and the most recent in 2012 in Lancet (65th). Eighty articles were published between 1990 and 2010. The number of citations

ranged from 667 to 4,666 (median 925). The leading country of origin was the United States with 39 articles, followed by articles originating from more than one country (30). There were 45 interventional studies (27 randomized controlled trials), 32 observational studies, 19 reviews and 4 guidelines, definitions or classifications. The level of evidence was low (IV) in 42 articles and high in 35 articles (Ia or Ib). A high number of citations did not reflect a high level of evidence. **Conclusions:** The topics and research questions of the identified articles covered a large area of visceral surgery. Some of the milestones in visceral surgery were identified. The high impact measured by citations did not reflect a high quality of research (level of evidence) in a considerable number of publications.

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Introduction

Visceral surgery originates from the Latin word 'viscera' meaning 'organs' [1]. It includes all organs of the digestive tract (i.e., esophagus, stomach, liver, bile ducts, pancreas, small and large intestine, anus), as well as the endocrine system and the abdominal wall.

Over the decades, the request for a continued improvement in highly specialized medicine demanded the for-

mation of separate societies, in order to regulate specialist training, represent the interests and concerns at all levels of health, and also provide support in science and practice [2].

Alongside the ongoing trend toward medical specialization, an increased understanding of pathogenesis, natural history and prognostic factors for progression and survival has led to major advances in interdisciplinary treatments. The implementation of these interdisciplinary, evidence-based concepts, which are the most promising future strategies, requires on the one hand a stable fundament of knowledge beyond speciality and gives disciplines as visceral surgery its right to exist. On the other hand, a critical evaluation of highly impacted articles is essential.

The number of citations of an article is a marker of its impact in a field [3]. Modern database, such as the Web of Science (Thomson Reuters, Philadelphia, Pa., USA), renders citation analysis as a tool of growing importance to identify high impact journals in different fields [4–6]. Therefore, the aim was to identify the 100 most cited articles in the field of visceral surgery, and to summarize the provided knowledge and evidence, focusing on those articles that influence and shape surgeon's daily decision making or have the potential to modify current therapeutic concepts.

Methods

Study Design

Bibliometric analysis is an extraction of statistics on journal articles in a research field. Its structure resembles the design of a systematic review [7]. Journal Citation Reports of Web of Science (Thomson Reuters, Philadelphia, Pa., USA) was used to obtain a list of all registered journals of the type 'Surgery' and of the 20 journals with the highest impact factor of the type 'Medicine, General & Internal' in the first 2 weeks of October 2015. Medical journals were screened to cover a wide range of visceral surgery articles. Science Citation Index Expanded was searched for citations of clinical visceral surgery articles published in the above journals.

Eligibility Criteria

A clinical visceral surgery article was defined by the following inclusion criteria: (i) content about visceral surgery, (ii) a research question that influences the surgeon's decision making or had the potential to modify a therapy concept, (iii) definitions, classifications and guidelines used in the daily clinical practice and (iv) no basic research or general epidemiology studies. The last criterion was set up to get a focus on the most cited clinical research. Therefore, studies reporting in general the incidence, risk factors and mortality of visceral diseases, obesity without measuring surgical outcomes or generating surgical strategies, as well as articles having the main focus on different disciplines (e.g., studies about *He-*

licobacter pylori, adjuvant radio- or chemotherapy or long-term course of immunosuppression after transplantation), were excluded. However, studies influencing the time point of operation (e.g., neoadjuvant therapy) were included.

Selection Process

After screening the 150 most cited articles (abstract and title) in 3 highly prestigious journals (Annals of Surgery, New England Journal of Medicine and Lancet), the assumption was made that the 100 most cited articles in visceral surgery would have been cited at least 500 times. Hence, all articles with less than 500 citations were excluded.

All articles of each journal identified by the aforementioned method were sorted by number of citations using Web of Science and articles with less than 500 citations were excluded. Next, non-eligible articles were excluded by the investigators (T.M. and M.M.) after analyzing independent titles, abstracts and full-text, if necessary.

After both authors had screened the articles for the first time, discrepancies were discussed, and the articles re-analyzed. If any disagreement persisted after the second screening and following discussion, the article was excluded. Sorting the included articles in descending order, the 100 most cited articles in visceral surgery were determined.

Data Extraction

In addition to the number of citations, the following data were extracted: title, journal, year of publication, authorship (first and senior author), country and city where the study was conducted, and impact factor of the journal where it was published. The articles were further characterized by the investigators (M.M. and T.M.) and discussed in the case of discrepancies.

- The main research topic of the article in the visceral surgery categories: General, Upper Gastrointestinal, Hepato-Pancreatico-Biliary, Bariatric, Colorectal, Endocrine or Traumatology.
- The type of study (observational, interventional, review or classification/guidelines and definitions) in accordance to the definition of European Network of Centres for Pharmacoepidemiology and Pharmacovigilance of an interventional study [8]. Interventional studies were further classified in multicenter randomized controlled trials (RCT), RCT conducted in a single center and others (i.e., pre-post intervention studies, non-controlled studies). Observational studies were grouped in case-control study, cohort study, case series and case reports. The proposal of Dekkers et al. [9] was used to distinguish between cohort study and case series.
- The level of evidence (I–IV) from Oxford Centre for Evidence-Based Medicine if appropriate.

Statistical Analysis

The data analysis was performed using Stata® 13.1 (StataCorp, College Station, Tex., USA). The distribution of a parameter (e.g., number of citations) was characterized by the median (range). The chi-square test was used to compare 2 categorical variables.

To test the hypothesis if 3 or more samples characterized by their medians originated from the same distribution, the Kruskal-Wallis test was conducted. In case of 2 samples, the rank sum test was used. The Spearman rank test was used to evaluate the correlation between the impact factor of a journal and the number of articles of a journal. The significance level was set to $p < 0.050$.

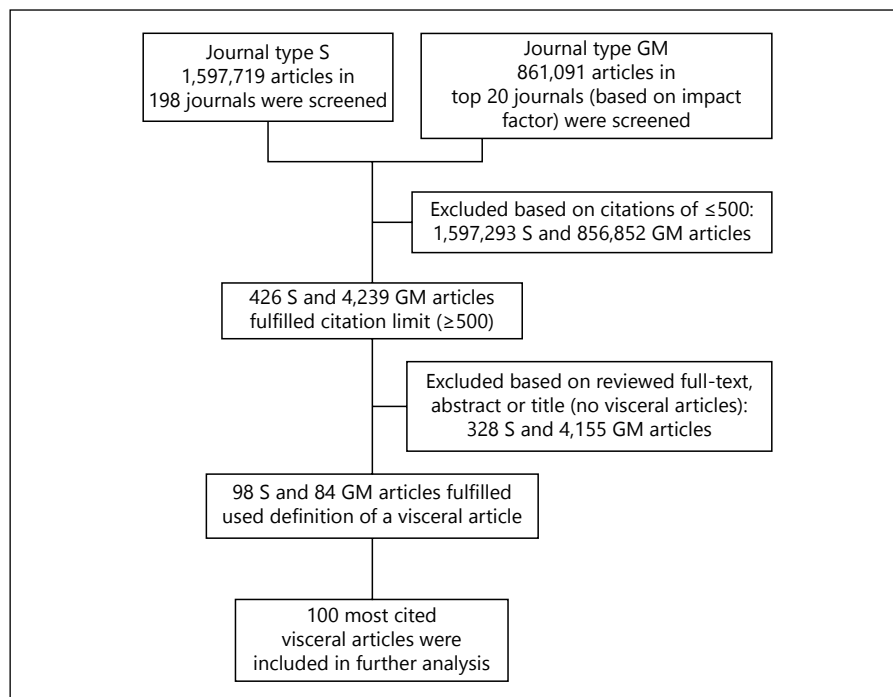


Fig. 1. Flow diagram showing the selection process of the 100 most cited articles. S = Surgery; GM = general medicine.

Results

A list of 198 journals of the type ‘Surgery’ and of the 20 journals with the highest impact factor of the type ‘Medicine, General and Internal’ was compiled. Applying the exclusion criterion ‘<500 citations’ and thereafter the inclusion criteria ‘visceral article’ (definition see above) on all articles in these journals, the 100 most cited articles in visceral surgery were identified (fig. 1). After the first screening, there were 53 articles with a different assessment (1.2% of disagreement). There was no persisting disagreement of the reviewers after the second screening.

The top 100 articles and their associated number of citations are shown in table 1.

The number of citations ranged from 667 to 4,666 with a median of 925.

The 100 articles were published in 17 of the 218 journals initially identified (table 2); 72 of the articles were published by 3 journals: *New England Journal of Medicine* (38), *Annals of Surgery* (21) and *Lancet* (13).

There was a significant correlation between the numbers of articles in top 100 of a journal and its impact factor (Spearman rank test, $r = 0.73$, $p < 0.010$).

The oldest article was published in 1908 in *Annals of Surgery* (ranked 76th) and the most recent in 2012 in *Lancet* (65th). Eighty articles were published between 1990 and 2009. There was no significant association between

the numbers of articles in a decade and the median citation ($p = 0.440$).

The distribution of the number of citations by type of study is shown in figure 2. There was a significant difference in the medians (Kruskal–Wallis test, $p = 0.050$): guidelines, definitions and classifications (median 1,705, range 866–4,350) were cited most followed by interventional (median 1,029, range 667–4,666), observational studies (median 912, range 671–2,162) and reviews (median 843, range 674–2,712).

The level of evidence of the systematic reviews, interventional and observational studies is shown in table 3. Thirteen of the reviews were articles giving a general overview about the current research status. No significant differences ($p = 0.581$) could be found between the citation medians of the articles and the level of evidence.

All articles were published in English. Countries of origin are shown in table 4.

There was an association ($p = 0.012$) between the type of article and the variable multiple country (participating institutions of at least 2 countries); there was no increased odd of being written by institutions of a single country for guidelines/definitions/classifications and for interventional study, whereas for reviews the odd was 3.75:1 and for observational studies 7:1. The median number of citations of articles written by investigators of one single or in more than one country did

Table 1. The 100 most cited articles in visceral surgery

Place	Article	Number of citations
1	Pugh RN: Transection of the oesophagus for bleeding oesophageal varices. <i>Br J Surg</i> 1973	4,666
2	Dindo D: Classification of surgical complications: a new proposal with evaluation in a cohort of 6,336 patients and results of a survey. <i>Ann Surg</i> 2004	4,350
3	Mazzaferro V: Liver transplantation for the treatment of small hepatocellular carcinomas in patients with cirrhosis. <i>N Engl J Med</i> 1996	3,178
4	Shapiro AM: Islet transplantation in seven patients with type 1 diabetes mellitus using a glucocorticoid-free immunosuppressive regimen. <i>N Engl J Med</i> 2000	2,961
5	Buchwald H: Bariatric surgery: a systematic review and meta-analysis. <i>JAMA</i> 2004	2,712
6	Llovet JM: Hepatocellular carcinoma. <i>Lancet</i> 2003	2,430
7	Demetri GD: Efficacy and safety of imatinib mesylate in advanced gastrointestinal stromal tumors. <i>N Engl J Med</i> 2002	2,414
8	Sauer R: Preoperative versus postoperative chemoradiotherapy for rectal cancer. <i>N Engl J Med</i> 2004	2,293
9	Birkmeyer JD: Hospital volume and surgical mortality in the United States. <i>N Engl J Med</i> 2002	2,162
10	Kapiteijn E: Preoperative radiotherapy combined with total mesorectal excision for resectable rectal cancer. <i>N Engl J Med</i> 2001	1,973
11	Cunningham D: Perioperative chemotherapy versus surgery alone for resectable gastroesophageal cancer. <i>N Engl J Med</i> 2006	1,774
12	Sjostrom L: Lifestyle, diabetes, and cardiovascular risk factors 10 years after bariatric surgery. <i>N Engl J Med</i> 2004	1,770
13	Lagergren J: Symptomatic gastroesophageal reflux as a risk factor for esophageal adenocarcinoma. <i>N Engl J Med</i> 1999	1,741
14	Bradley EL: A clinically based classification system for acute pancreatitis. Summary of the international symposium on acute pancreatitis, Atlanta, Ga, September 11 through 13, 1992. <i>Arch Surg</i> 1993	1,707
15	Bassi C: Postoperative pancreatic fistula: an international study group (ISGPF) definition. <i>Surgery</i> 2005	1,703
16	Fong Y: Clinical score for predicting recurrence after hepatic resection for metastatic colorectal cancer: analysis of 1,001 consecutive cases. <i>Ann Surg</i> 1999	1,658
17	Sjostrom L: Effects of bariatric surgery on mortality in Swedish obese subjects. <i>N Engl J Med</i> 2007	1,634
18	Macdonald JS: Chemoradiotherapy after surgery compared with surgery alone for adenocarcinoma of the stomach or gastroesophageal junction. <i>N Engl J Med</i> 2001	1,618
19	A comparison of laparoscopically assisted and open colectomy for colon cancer, clinical outcomes of surgical therapy study group. <i>N Engl J Med</i> 2004	1,443
20	Haynes AB: A surgical safety checklist to reduce morbidity and mortality in a global population. <i>N Engl J Med</i> 2009	1,336
21	Mazzaferri EL: Long-term impact of initial surgical and medical therapy on papillary and follicular thyroid cancer. <i>Am J Med</i> 1994	1,329
22	Birkmeyer JD: Surgeon volume and operative mortality in the United States. <i>N Engl J Med</i> 2003	1,310
23	DeMatteo RP: Two hundred gastrointestinal stromal tumors: recurrence patterns and prognostic factors for survival. <i>Ann Surg</i> 2000	1,298
24	Krook JE: Effective surgical adjuvant therapy for high-risk rectal carcinoma. <i>N Engl J Med</i> 1991	1,285
25	Joensuu H: Effect of the tyrosine kinase inhibitor STI571 in a patient with a metastatic gastrointestinal stromal tumor. <i>N Engl J Med</i> 2001	1,274

Table 1. (continued)

Place	Article	Number of citations
26	Enzinger PC: Esophageal cancer. <i>N Engl J Med</i> 2003	1,269
27	Warshaw AL: Pancreatic carcinoma. <i>N Engl J Med</i> 1992	1,263
28	Walsh TN: A comparison of multimodal therapy and surgery for esophageal adenocarcinoma. <i>N Engl J Med</i> 1996	1,240
29	Heald RJ: The mesorectum in rectal cancer surgery – the clue to pelvic recurrence? <i>Br J Surg</i> 1982	1,240
30	Guillou PJ: Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicentre, randomised controlled trial. <i>Lancet</i> 2005	1,237
31	Herskovic A: Combined chemotherapy and radiotherapy compared with radiotherapy alone in patients with cancer of the esophagus. <i>N Engl J Med</i> 1992	1,231
32	Yeo CJ: Six hundred fifty consecutive pancreaticoduodenectomies in the 1990s: pathology, complications, and outcomes. <i>Ann Surg</i> 1997	1,214
33	Lacy AM: Laparoscopy-assisted colectomy versus open colectomy for treatment of non-metastatic colon cancer: a randomised trial. <i>Lancet</i> 2002	1,213
34	Improved survival with preoperative radiotherapy in resectable rectal cancer. Swedish Rectal Cancer Trial, Swedish Rectal Cancer Trial Group. <i>N Engl J Med</i> 1997	1,194
35	Pories WJ: Who would have thought it? An operation proves to be the most effective therapy for adult-onset diabetes mellitus. <i>Ann Surg</i> 1995	1,193
36	Gauderer MW: Gastrostomy without laparotomy: a percutaneous endoscopic technique. <i>J Pediatr Surg</i> 1980	1,160
37	Quirke P: Local recurrence of rectal adenocarcinoma due to inadequate surgical resection. Histopathological study of lateral tumour spread and surgical excision. <i>Lancet</i> 1986	1,113
38	Heald RJ: Recurrence and survival after total mesorectal excision for rectal cancer. <i>Lancet</i> 1986	1,096
39	Sollinger HW: Mycophenolate mofetil for the prevention of acute rejection in primary cadaveric renal allograft recipients. U.S. Renal Transplant Mycophenolate Mofetil Study Group. <i>Transplantation</i> 1995	1,075
40	Jorge JM: Etiology and management of fecal incontinence. <i>Dis Colon Rectum</i> 1993	1,034
41	Seymour NE: Virtual reality training improves operating room performance: results of a randomized, double-blinded study. <i>Ann Surg</i> 2002	1,029
42	Bosset JF: Chemotherapy with preoperative radiotherapy in rectal cancer. <i>N Engl J Med</i> 2006	1,027
43	Scheele J: Resection of colorectal liver metastases. <i>World J Surg</i> 1995	1,020
44	Belzer FO: Principles of solid-organ preservation by cold storage. <i>Transplantation</i> 1988	991
45	Adams TD: Long-term mortality after gastric bypass surgery. <i>N Engl J Med</i> 2007	984
46	Argenta LC: Vacuum-assisted closure: a new method for wound control and treatment: clinical experience. <i>Ann Plast Surg</i> 1997	982
47	Calne RY: Cyclosporin A in patients receiving renal allografts from cadaver donors. <i>Lancet</i> 1978	973
48	Li D: Pancreatic cancer. <i>Lancet</i> 2004	970
49	Bonenkamp JJ: Extended lymph-node dissection for gastric cancer. <i>N Engl J Med</i> 1999	947
50	MacFarlane JK: Mesorectal excision for rectal cancer. <i>Lancet</i> 1993	946
51	Clavien PA: The Clavien–Dindo classification of surgical complications: five-year experience. <i>Ann Surg</i> 2009	944
52	Lowenfels AB: Pancreatitis and the risk of pancreatic cancer. International Pancreatitis Study Group. <i>N Engl J Med</i> 1993	935

Table 1. (continued)

Place	Article	Number of citations
53	Shapiro AM: International trial of the Edmonton protocol for islet transplantation. <i>N Engl J Med</i> 2006	934
54	Astler VB: The prognostic significance of direct extension of carcinoma of the colon and rectum. <i>Ann Surg</i> 1954	922
55	Trede M: Survival after pancreatoduodenectomy. 118 consecutive resections without an operative mortality. <i>Ann Surg</i> 1990	915
56	Begg CB: Impact of hospital volume on operative mortality for major cancer surgery. <i>JAMA</i> 1998	909
57	Classen DC: The timing of prophylactic administration of antibiotics and the risk of surgical-wound infection. <i>N Engl J Med</i> 1992	886
58	Whipple AO: Treatment of carcinoma of the ampulla of vater. <i>Ann Surg</i> 1935	885
59	Patel R: Significance of the positive crossmatch test in kidney transplantation. <i>N Engl J Med</i> 1969	876
60	Edge SB: The American Joint Committee on Cancer: the 7th edition of the AJCC cancer staging manual and the future of TNM. <i>Ann Surg Oncol</i> 2010	866
61	Bosset JF: Chemoradiotherapy followed by surgery compared with surgery alone in squamous-cell cancer of the esophagus. <i>N Engl J Med</i> 1997	847
62	Kehlet H: Persistent postsurgical pain: risk factors and prevention. <i>Lancet</i> 2006	843
63	Moore FA: Early enteral feeding, compared with parenteral, reduces postoperative septic complications. The results of a meta-analysis. <i>Ann Surg</i> 1992	840
64	Starzl TE: FK 506 for liver, kidney, and pancreas transplantation. <i>Lancet</i> 1989	831
65	Fornier A: Hepatocellular carcinoma. <i>Lancet</i> 2012	816
66	Martin JA: Objective structured assessment of technical skill (OSATS) for surgical residents. <i>Br J Surg</i> 1997	814
67	Abdalla EK: Recurrence and outcomes following hepatic resection, radiofrequency ablation, and combined resection/ablation for colorectal liver metastases. <i>Ann Surg</i> 2004	810
68	Pirsch JD: A comparison of tacrolimus (FK506) and cyclosporine for immunosuppression after cadaveric renal transplantation. FK506 Kidney Transplant Study Group. <i>Transplantation</i> 1997	810
69	Sohn TA: Resected adenocarcinoma of the pancreas-616 patients: results, outcomes, and prognostic indicators. <i>J Gastrointest Surg</i> 2000	808
70	Earlam R: Oesophageal squamous cell carcinoma: I. A critical review of surgery. <i>Br J Surg</i> 1980	803
71	Hidalgo M: Pancreatic cancer. <i>N Engl J Med</i> 2010	798
72	Deziel DJ: Complications of laparoscopic cholecystectomy: a national survey of 4,292 hospitals and an analysis of 77,604 cases. <i>Am J Surg</i> 1993	789
73	Nordlinger B: Perioperative chemotherapy with FOLFOX4 and surgery versus surgery alone for resectable liver metastases from colorectal cancer (EORTC Intergroup trial 40,983): a randomised controlled trial. <i>Lancet</i> 2008	782
74	El-Serag HB: Hepatocellular carcinoma. <i>N Engl J Med</i> 2011	776
75	Kelsen DP: Chemotherapy followed by surgery compared with surgery alone for localized esophageal cancer. <i>N Engl J Med</i> 1998	765
76	Pringle JH: V. Notes on the arrest of hepatic hemorrhage due to trauma. <i>Ann Surg</i> 1908	760
77	Heald RJ: Rectal cancer: the Basingstoke experience of total mesorectal excision, 1978–1997. <i>Arch Surg</i> 1998	758
78	Schauer PR: Outcomes after laparoscopic Roux-en-Y gastric bypass for morbid obesity. <i>Ann Surg</i> 2000	755
79	A blinded, randomized clinical trial of mycophenolate mofetil for the prevention of acute rejection in cadaveric renal transplantation. The Tricontinental Mycophenolate Mofetil Renal Transplantation Study Group. <i>Transplantation</i> 1996	749

Table 1. (continued)

Place	Article	Number of citations
80	Terasaki PI: High survival rates of kidney transplants from spousal and living unrelated donors. <i>N Engl J Med</i> 1995	748
81	Hulscher JB: Extended transthoracic resection compared with limited transhiatal resection for adenocarcinoma of the esophagus. <i>N Engl J Med</i> 2002	747
82	Kudsk KA: Enteral versus parenteral feeding. Effects on septic morbidity after blunt and penetrating abdominal trauma. <i>Ann Surg</i> 1992	746
83	Turnbull RB Jr: Cancer of the colon: the influence of the no-touch isolation technic on survival rates. <i>Ann Surg</i> 1967	738
84	Choti MA: Trends in long-term survival following liver resection for hepatic colorectal metastases. <i>Ann Surg</i> 2002	727
85	Samuel D: Liver transplantation in European patients with the hepatitis B surface antigen. <i>N Engl J Med</i> 1993	720
86	Cohen DJ: Cyclosporine: a new immunosuppressive agent for organ transplantation. <i>Ann Intern Med</i> 1984	717
87	Adam R: Rescue surgery for unresectable colorectal liver metastases downstaged by chemotherapy: a model to predict long-term survival. <i>Ann Surg</i> 2004	717
88	Siewert JR: Relevant prognostic factors in gastric cancer: ten-year results of the German Gastric Cancer Study. <i>Ann Surg</i> 1998	717
89	Surgical resection with or without preoperative chemotherapy in oesophageal cancer: a randomised controlled trial, Medical Research Council Oesophageal Cancer Working Group. <i>Lancet</i> 2002	715
90	Muller JM: Surgical therapy of oesophageal carcinoma. <i>Br J Surg</i> 1990	706
91	Maggard MA: Meta-analysis: surgical treatment of obesity. <i>Ann Intern Med</i> 2005	703
92	Yeo CJ: Pancreaticoduodenectomy for cancer of the head of the pancreas. 201 patients. <i>Ann Surg</i> 1995	696
93	Ratner LE: Laparoscopic live donor nephrectomy. <i>Transplantation</i> 1995	696
94	Bismuth H: Liver resection versus transplantation for hepatocellular carcinoma in cirrhotic patients. <i>Ann Surg</i> 1993	693
95	Colombo M: Hepatocellular carcinoma in Italian patients with cirrhosis. <i>N Engl J Med</i> 1991	686
96	Luijendijk RW: A comparison of suture repair with mesh repair for incisional hernia. <i>N Engl J Med</i> 2000	678
97	Todani T: Congenital bile duct cysts: classification, operative procedures, and review of thirty-seven cases including cancer arising from choledochal cyst. <i>Am J Surg</i> 1977	674
98	Dixon JB: Adjustable gastric banding and conventional therapy for type 2 diabetes: a randomized controlled trial. <i>JAMA</i> 2008	671
99	Ploeg RJ: Risk factors for primary dysfunction after liver transplantation – a multivariate analysis. <i>Transplantation</i> 1993	671
100	Ekberg H: Reduced exposure to calcineurin inhibitors in renal transplantation. <i>N Engl J Med</i> 2007	667

not differ meaningfully. Articles with higher levels of evidence involved arose more often from international collaborations. Of the 29 studies with a high level of evidence of Ib and of the 42 studies with level of evidence IV, 26 and 68%, respectively, were conducted in a single country.

About half of the studies (48%) were conducted by a group of authors of at least 2 different cities. Five cities could be identified with more than 2 articles in the top 100: 5 articles each were written by investigators affiliated with institutions in Baltimore and New York, and 3 articles each by investigators based in Boston, Cleveland and

Table 2. Journals in which the 100 top cited articles were published with the corresponding impact factors at the time of review

Journal	Number of articles	Total articles	Impact factor
New England Journal of Medicine	38	97,856	55.873
Annals of Surgery	21	47,315	8.327
Lancet	13	320,500	45.217
Transplantation	6	52,232	3.828
British Journal of Surgery	5	38,532	5.542
Journal of the American Medical Association	3	104,559	35.289
American Journal of Surgery	2	46,365	2.291
Annals of Internal Medicine	2	66,644	17.810
Archives of Surgery	2	19,287	4.926
American Journal of Medicine	1	25,019	5.003
Annals of Plastic Surgery	1	18,923	1.494
Annals of Surgical Oncology	1	20,344	3.930
Diseases of the Colon & Rectum	1	6,937	2.449
Journal of Gastrointestinal Surgery	1	4,549	2.798
Journal of Pediatric Surgery	1	32,684	1.387
Surgery	1	41,822	3.380
World Journal of Surgery	1	18,349	2.642

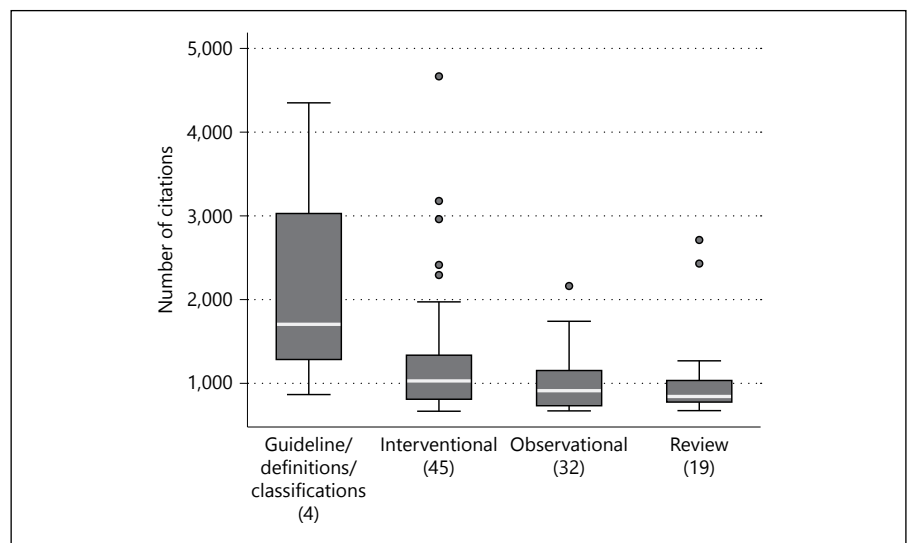


Fig. 2. Type of article and associated number of citations of the 100 most cited articles. In brackets is the number of articles in the particular category.

Houston. In 20 articles, a study group was declared to be the author. No difference in median number of citations could be found between articles of declared study groups and non-study groups with a median number of authors of 6 (range 1–21). First and last authors with more than one published article in the top 100 are shown in table 4.

No significant differences ($p = 0.058$) could be found between the median number of citation of the articles and their topics (table 5).

Figure 3 illustrates the cumulative numbers of articles over time by surgical speciality.

Discussion

Bibliometric analysis is used to measure the impact of a paper. To our knowledge this is the first citation analysis in the field of visceral surgery. The 100 most-cited articles in clinical visceral surgery were identified.

Strengths of the study are (i) an accepted and often used technical method, (ii) inclusion and exclusion criteria leading to a high inter-rater reliability and (iii) quality control through systematic review of the references independently by 2 investigators and discussion of inconsistencies.

Table 3. The distribution of the level of evidence in different types of articles

Level of evidence	Type of study		Review	Total*
	interventional	observational		
–	–	–	13	13
1a	–	–	6	6
1b	29	–	–	29
2b	–	4	–	4
3b	–	2	–	2
4	16	26	–	42

* Missing: 4 classification, guidelines or definitions.

There are also some limitations of the study. By taking medical journals with a high impact factor into account, more important papers of visceral surgery could be identified and the internal validity increased. Nevertheless, visceral surgery covers a wide research area and some excluded medical journals especially journals mainly focusing on topics of gastroenterology might contain highly cited articles. Especially, the journals that were not indexed by Web of Science, hence articles and otherwise published research, could not be identified. On the other hand, it seems unlikely that such an article might have a high impact. Despite the advantage of clear inclusion criteria leading to a ‘clean’ list, the important subgroup of basic research, often the fundamental of clinical research, was excluded. This was done to identify highly cited articles of surgeon’s decision-making only, but needs to be considered when interpreting the results. Last, this study is limited by the nature of the research publication dynamics, which includes (i) different kind of publication biases as language and predominance of positive findings, journal preferences when citing, persuading-the-reader, self-citation, and omission-by-contributor bias [6], (ii) missing of recent and older milestones as citations need to accumulate over time and will decrease after a while [3], (iii) shortness of publications bias, that is, gaining impact due to lack of alternatives (e.g., articles about rare diseases) and (iv) citation frequency as a multidimensional function of many different variables (e.g., author’s reputation, availability, controversiality including ethical issues and etiology) [10].

The impact factor of a journal was identified as the best predictor of the number of citations of an article [11]. This was confirmed by our analysis as the majority of 72% of the identified articles were found in the journals with the highest impact factor in surgery (Annals of Surgery)

Table 4. Countries of origin and authors with more than one published article in the top 100

Country	Number of articles
USA	39
Several	30
Great Britain	8
Germany	5
Netherlands	3
Spain	3
Canada	2
France	2
Italy	2
Sweden	2
Australia, Ireland, Japan, Switzerland	1
<i>First author</i>	
Heald RJ	3
Birkmeyer JD	2
Bosset JF	2
Shapiro AM	2
Sjostrom L	2
Yeo CJ	2
<i>Last author</i>	
Bismuth H	2
Brennan MF	2
Bruix J	2
Ryall RD	2

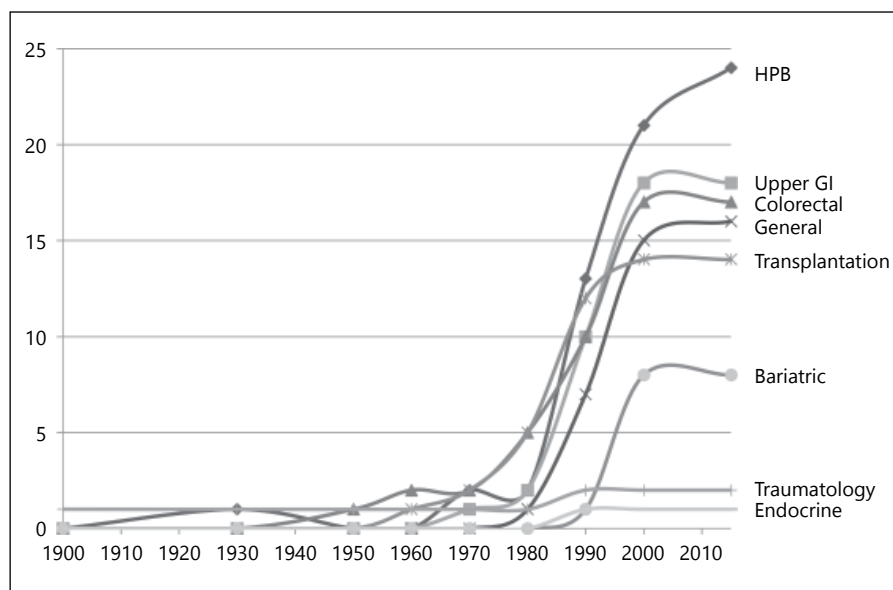
Table 5. Topics and number of citations of the 100 top cited articles

Topic	Number of articles	Number of citations, median (range)
Hepato-Pancreatico-Biliary	24	900 (674–3,178)
Upper Gastrointestinal	18	1,236 (706–4,666)
Colorectal	17	1,113 (738–2,293)
General	16	927 (678–4,350)
Transplantation	14	780 (667–1,075)
Bariatric	8	1,089 (671–2,712)
Traumatology	2	753 (746–760)
Endocrine	1	1,329

and general medicine (New England Journal of Medicine and Lancet). However, the impact factor was recorded at the time of review. Therefore, there might be a bias as by the time of publication of an article; a high impacted journal had a low impact at the time of recording and vice versa.

The fact that only 4 articles were published after 2009, and 80 articles were published between 1990 and 2009 reflects the fact that it takes some time for an article to

Fig. 3. Cumulative numbers of articles over time by surgical speciality. HPB = Hepato-Pancreatico-Biliary.



gain citations [3]. The peak period is closer to the present time than it was found in other citation analysis studies [12, 13]. This may indicate that visceral surgery is a young and dynamic field, and clinicians rely on latest research as suggested by Shuaib et al. [5] analyzing highly cited papers in the cardiovascular area.

The quality of research measured by the level of evidence of the cited articles showed 2 peaks: first, 51% of the 83 articles, where a level of evidence was applicable, were interventional and observational studies with a low level of evidence (IV) and second, 42% were systematic reviews and RCT with a high level of evidence (Ia or Ib). This could be explained that besides the citation of reliable high quality research, non-controlled interventional studies and case series with innovative ideas and surgical procedures (e.g. No. 36, 93).

Besides the well-known fact that in citation analysis there is often a high proportion (in the case of our study 39%) of articles originating from the United States due to citation and reviewer behavior as well as socioeconomic factors [4, 5, 14], a high proportion of the articles originated from institutions of more than one country. This underlines the trend to international collaboration studies, which are associated with a higher level of evidence in this study.

Studying the topics in combination with the different types of articles revealed a broad and heterogeneous spectrum. Safety and quality issues, illustrating the efforts in the area of surgeries' quality assurance, are prominent in the ranking (No. 2, 9, 20). Looking at citations per year in

this area, the 10 most cited publications were published exclusively since 2000, with a global safety checklist from 2009 being the most recent work in the top 10. In order to report and compare surgical outcomes and quality, clear definitions of what is treated and how complications are managed are of paramount importance and not only crude figures (e.g., mortality) need to be reported. Also, definitions and scores leading to therapy concepts (No. 16, 97) for visceral surgery are highly ranked. Accordingly, among the highest ranked 25 publications, there are 7 related to quality assessment, definitions and scores. In this context, a standardized classification of surgical complications, which guides clinicians in daily practice, was identified (No. 2).

Reflecting obesity-associated morbidity seen in recent years and the commendatory scientific surgical approach, 5 papers on bariatric surgery including the ancestor (No. 12) appear among the top 100 in this rising speciality illustrated by figure 3 [15] (No. 5, 12, 17, 78, 91).

As expected several publications on clinical oncological treatment concepts, which cover a broad spectrum of diseases and interdisciplinary decision-making (e.g. No. 3, 8, 11, 21, 31, 52) were found. The first 10 oncology articles revealed 4 papers focusing on colorectal cancer, 3 on neoplasia of the upper GI tract, 1 in the hepatopancreaticobiliary field and 1 for the management of thyroid cancer. Surprisingly, a publication about the treatment of gastrointestinal stromal tumors, a rare tumor entity [16], appeared in the top 10 (No. 7). The most cited article on hepatocellular carcinoma (No. 3) is considered as a land-

mark in the field; it showed that transplantation is a promising treatment option and is known as the ‘Milan criteria’. While the significance of the ‘Milan criteria’ were recently confirmed by an international consensus meeting [17], another identified important clinically used classification, the Atlanta classification of acute pancreatitis from the year 1992 (No. 14), had to be revised due to an improved understanding of the underlying pathophysiology in 2012 [18]. This illustrates the aforementioned fact that bibliometric studies might also identify citation classics that have been overruled by new evidence and knowledge.

In conclusion, despite the existing limitations of citation analysis, its use to identify some classic works for a better understanding of history and development of vis-

ceral surgery could be achieved. Nevertheless, citation does not equal clinical practice. It might simply represent a definition that is used for research but has limited clinical relevance. Number of citations do not translate a level of evidence and should therefore be assessed critically.

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