Original Article

The 100 most cited manuscripts in esophageal motility disorders: a bibliometric analysis

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Background: The use of bibliometrics can help us identify the most impactful articles on a topic or scientific discipline and their influence on clinical practice. We aimed to identify the 100 most cited articles covering esophageal motility disorders and examine their key characteristics.

Methods: The Web of Science database was utilized to perform the search, using predefined search terms. The returned dataset was filtered to include full manuscripts written in the English language. After screening, we identified the 100 most cited articles and analyzed them for title, year of publication, names of authors, institution, country of the first author, number of citations and citation rate.

Results: The initial search returned 29,521 results. The top 100 articles received a total of 20,688 citations. The most cited paper was by Inoue *et al.* (665 citations) who first described peroral endoscopic myotomy (POEM) for treating achalasia. The article with the highest citation rate was the third version of the Chicago Classification system, written by Kahrilas and colleagues. *Gastroenterology* published most papers on the list (n=32) and accrued the highest number of citations (6,675 citations). Peter Kahrilas was the most cited author (3,650 citations) and, along with Joel Richter, authored the highest number of manuscripts (n=14). Most articles were produced in the USA (n=66) between the years 1991 and 2000 (n=32).

Conclusions: By analyzing the most influential articles, this work is a reference on the articles that shaped our understanding of esophageal motility disorders, thus serving as a guide for future research.

Keywords: Esophageal disease; motility disorders; bibliometric analysis; citations

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Introduction

Esophageal motility disorders are a large group of pathologic conditions that involve both primary and secondary disorders of esophageal contraction (1). Motility disorders are considered to be primary if symptoms, such as dysphagia and chest pain, originate from the esophagus, and no other cause can be identified (1). The main primary conditions are achalasia, diffuse (distal) esophageal spasm, nutcracker esophagus, and hypertensive lower esophageal sphincter (1). The evaluation of esophageal motility

disorders is mainly based on the use of manometry, and their classification is made according to the Chicago Classification system, which utilizes high-resolution manometry (HRM) (2). Although there is a fair amount of evidence for some of these disorders, such as achalasia, the data on others is not as granular.

Bibliometric citation analysis is a quantitative method that uses the number of citations received by scientific articles to develop citation ranking lists, in order to assess the quality and scientific impact of those articles (3). A publication receives a citation when another peer-reviewed publication references it. By establishing citation ranking lists, we can identify the most influential articles on a specific topic or scientific discipline and their impact on clinical practice. Bibliometric analysis can also provide insight into how our understanding of those topics or disciplines has evolved over the years (3).

In recent years, bibliometric citation analysis has been used to identify the most influential articles in various medical disciplines and specialties, such as plastic (4), orthopaedic (5), general (6), and emergency general surgery (7) as well as oncology (8). To date, the only bibliometric analysis in the field of esophageal diseases is on the topic of esophageal cancer (9). The purpose of this study is to determine which articles are the most cited and, therefore, influential on the subject of esophageal motility disorders and to examine how our understanding of these diseases has changed over time. It also aims to serve as a concise reference for the most cited papers on the subject.

Methods

Search methodology

The Web of Science citation indexing database and research platform of Clarivate Analytics was used to perform the study. The search strategy was to identify articles that contained specific search terms/keywords in their title, abstract or topic. After independent trial searches by two authors (P Kapsampelis, D Schizas), the following keywords were agreed upon and used in the final search: (esophag* OR oesophag*) AND (achalasia OR motility OR dysmotility OR spasm OR peristal* OR hypercontract* OR nutcracker OR hypertens* OR hypotens* OR sphincter* OR contraction* OR manometry OR dysphagia OR obstruction). The search was set to include results from all the databases within the Web of Science and all available years [1900–2018]. Also, it was set to include articles written only in the English language. The final search date was August 15th, 2018. This strategy is a modified version of the method initially developed by Paladugu and colleagues (6).

Article selection

The returned results were sorted by the total number of citations, in descending order, and reviewed for inclusion, with the article with the most citations examined first. Papers focusing on esophageal motility disorders as their main topic and written in the English language were included. The exclusion criteria were: (I) articles written in any language other than English; (II) articles irrelevant to the subject; or (III) articles focusing on broader topics, such as esophageal and gastrointestinal diseases in general, without giving specific emphasis to esophageal motility disorders.

Initially, two reviewers (P Kapsampelis, D Schizas) independently assessed abstracts for inclusion. Consequently, the two lists were compared and full manuscripts of articles were reviewed, when deemed necessary. After conflicts were resolved by a third author (DI Tsilimigras) and the list of 100 most cited papers was finalized, the full manuscripts of included papers were analyzed to extract the data of interest.

Data extraction

The 100 most cited articles were analyzed for title, names of first author and co-authors, institution and country of the first author, year of publication, total number of citations and citation rate. The ranking within the 100 most cited papers list was also recorded. The purpose of calculating the citation rate was to control for historical publication bias since older articles can accumulate more citations over time. In a method described by Powell *et al.* (10), the citation rate is calculated by dividing a publication's number of citations by the number of years since its publication. Also, in the case of articles with same citation numbers, the ranking was done according to the citation rate and articles that received the same number of citations in a shorter period of time were ranked higher.

Results

The Web of Science search returned 29,521 full-length, English language papers. *Table 1* lists the 100 most cited papers. The total cumulative number of citations received by the top 100 articles was 20,688. The article with the

Table 1 The top 100 cited papers on esophageal motility disorders

Rank	Title of article	Authors	Number of citations
1	Peroral endoscopic myotomy (POEM) for esophageal achalasia (11)	Inoue *et al.*	665
2	Esophageal peristaltic dysfunction in peptic esophagitis (12)	Kahrilas *et al.*	526
3	Esophageal manometry in 95 healthy adult volunteers-variability of pressures with age and frequency of "abnormal" contractions (13)	Richter *et al.*	439
4	Classification of oesophageal motility abnormalities (14)	Spechler *et al.*	428
5	Effect of peristaltic dysfunction on esophageal volume clearance (15)	Kahrilas *et al.*	414
6	Chicago classification criteria of esophageal motility disorders defined in high resolution esophageal pressure topography (16)	Bredenoord *et al.*	412
7	The Chicago classification of esophageal motility disorders, v3.0 (17)	Kahrilas *et al.*	392
8	Achalasia: a new clinically relevant classification by high-resolution manometry (18)	Pandolfino *et al.*	378
9	Intrasphincteric botulinum toxin for the treatment of achalasia (19)	Pasricha *et al.*	376
10	Esophageal testing of patients with noncardiac chest pain or dysphagia: results of three years' experience with 1,161 patients (20)	Katz *et al.*	375
11	Pneumatic dilation versus laparoscopic Heller's myotomy for idiopathic achalasia (21)	Boeckxstaens *et al.*	359
12	Endoscopic and surgical treatments for achalasia: a systematic review and meta-analysis (22)	Campos *et al.*	349
13	Late results of a prospective randomised study comparing forceful dilatation and oesophagomyotomy in patients with achalasia (23)	Csendes *et al.*	336
14	Predictors of outcome in patients with achalasia treated by pneumatic dilation (24)	Eckardt *et al.*	327
15	Heller myotomy versus Heller myotomy with dor fundoplication for achalasia: a prospective randomized double-blind clinical trial (25)	Richards *et al.*	284
16	Botulinum toxin for achalasia: long-term outcome and predictors of response (26)	Pasricha *et al.*	276
17	Achalasia, diffuse esophageal spasm, and related motility disorders (27)	Vantrappen *et al.*	265
18	Eosinophilic esophagitis in a patient with vigorous achalasia (28)	Landres *et al.*	259
19	High amplitude, peristaltic esophageal contractions associated with chest pain and/or dysphagia (29)	Benjamin *et al.*	257
20	Submucosal endoscopic esophageal myotomy: a novel experimental approach for the treatment of achalasia (30)	Pasricha *et al.*	251
21	Mechanisms of gastroesophageal reflux in ambulant healthy human subjects (31)	Schoeman *et al.*	245
22	Achalasia of the esophagus: pathologic and etiologic considerations (32)	Cassella *et al.*	244
23	Minimally invasive surgery for achalasia: an 8-year experience with 168 patients (33)	Patti *et al.*	240
24	Relationships between oesophageal transit and solid and liquid gastric emptying in diabetes mellitus (34)	Horowitz *et al.*	239
25	Psychiatric illness and contraction abnormalities of the esophagus (35)	Clouse *et al.*	230
26	Patients with achalasia lack nitric oxide synthase in the gastro-oesophageal junction (36)	Mearin *et al.*	226
27	Low-dose trazodone for symptomatic patients with esophageal contraction abnormalities: a double-blind, placebo-controlled trial (37)	Clouse *et al.*	226
28	American gastroenterological association technical review on the clinical use of esophageal manometry (38)	Kahrilas *et al.*	218

Table 1 *(continued)*

Table 1 *(continued)*

Rank	Title of article	Authors	Number of citations
29	Etiology and pathogenesis of achalasia: the current understanding (39)	Park *et al.*	213
30	Esophageal lewy bodies associated with ganglion cell loss in achalasia. Similarity to Parkinson's disease (40)	Qualman *et al.*	213
31	Thoracoscopic esophagomyotomy. Initial experience with a new approach for the treatment of achalasia (41)	Pellegrini *et al.*	207
32	Peroral endoscopic myotomy for the treatment of achalasia: a prospective single center study (42)	von Renteln *et al.*	205
33	Classifying esophageal motility by pressure topography characteristics: a study of 400 patients and 75 controls (43)	Pandolfino *et al.*	204
34	Oesophageal high-resolution manometry: moving from research into clinical practice (44)	Fox *et al.*	203
35	Ineffective esophageal motility (IEM): the primary finding in patients with nonspecific esophageal motility disorder (45)	Leite *et al.*	200
36	Spontaneous noncardiac chest pain. Evaluation by 24-hour ambulatory esophageal motility and pH monitoring (46)	Peters *et al.*	200
37	Treating achalasia: from whalebone to laparoscope (47)	Spiess *et al.*	198
38	The concept of sphincter substitution by an interposed jejunal segment for anatomic and physiologic abnormalities at the esophagogastric junction (48)	Merendino *et al.*	197
39	Pneumatic dilation for achalasia: late results of a prospective follow up investigation (49)	Eckardt *et al.*	192
40	Esophagomyotomy versus forceful dilation for achalasia of the esophagus: results in 899 patients (50)	Okike *et al.*	191
41	Laparoscopic Heller myotomy and fundoplication for achalasia (51)	Hunter *et al.*	188
42	Achalasia: a morphologic study of 42 resected specimens (52)	Goldblum *et al.*	187
43	Oesophageal motility disorders (53)	Richter *et al.*	183
44	Prospective manometric evaluation with pharmacologic provocation of patients with suspected esophageal motility dysfunction (54)	Benjamin *et al.*	183
45	Aga technical review on the clinical use of esophageal manometry (55)	Pandolfino *et al.*	181
46	Long-term outcomes of an endoscopic myotomy for achalasia: the poem procedure (56)	Swanstrom *et al.*	180
47	Botulinum toxin versus pneumatic dilatation in the treatment of achalasia: a randomized trial (57)	Vaezi *et al.*	180
48	Five year prospective study of the incidence, clinical features, and diagnosis of achalasia in Edinburgh (58)	Howard *et al.*	178
49	Current therapies for achalasia: comparison and efficacy (59)	Vaezi *et al.*	176
50	Oral nifedipine in the treatment of noncardiac chest pain in patients with the nutcracker esophagus (60)	Richter *et al.*	172
51	Instrumentation and methods for intraluminal esophageal manometry (61)	Dodds *et al.*	172
52	ACG clinical guideline—diagnosis and management of achalasia (62)	Vaezi *et al.*	170
53	Improved outcome after extended gastric myotomy for achalasia (63)	Oelschlager *et al.*	167
54	Diffuse esophageal spasm: a reappraisal (64)	Richter *et al.*	166
55	Primary treatment of esophageal achalasia: long term results of myotomy and dor fundoplication (65)	Bonavina *et al.*	165

Table 1 *(continued)*

Table 1 *(continued)*

Rank	Title of article	Authors	Number of citations
56	Combined multichannel intraluminal impedance and manometry clarifies esophageal function abnormalities: study in 350 patients (66)	Tutuian *et al.*	163
57	Histopathologic features in esophagomyotomy specimens from patients with achalasia (67)	Goldblum *et al.*	163
58	Mechanisms of oral-pharyngeal dysphagia in patients with Parkinson's disease (68)	Ali *et al.*	161
59	Pharyngeal (Zenker's) diverticulum is a disorder of upper esophageal sphincter opening (69)	Cook *et al.*	161
60	Relevance of ineffective oesophageal motility during oesophageal acid clearance (70)	Simrén *et al.*	160
61	Clinical and manometric effects of nifedipine in patients with esophageal achalasia (71)	Bortolotti *et al.*	160
62	Presbyesophagus: esophageal motility in nonagenarians (72)	Soergel *et al.*	159
63	High-resolution manometry in clinical practice: utilizing pressure topography to classify oesophageal motility abnormalities (73)	Pandolfino *et al.*	157
64	Peroral endoscopic myotomy for the treatment of achalasia: an international prospective multicenter study (74)	von Renteln *et al.*	156
65	Achalasia (75)	Boeckxstaens *et al.*	155
66	High-resolution manometry predicts the success of oesophageal bolus transport and identifies clinically important abnormalities not detected by conventional manometry (76)	Fox *et al.*	152
67	Impaired deglutitive EGJ relaxation in clinical esophageal manometry: a quantitative analysis of 400 patients and 75 controls (77)	Ghosh *et al.*	149
68	The effects of recombinant human hemoglobin on esophageal motor function in humans (78)	Murray *et al.*	149
69	Altered swallowing function in elderly patients without dysphagia (79)	Ekberg *et al.*	149
70	Pattern of esophageal motility in diffuse spasm (80)	Creamer *et al.*	148
71	A prospective randomized study comparing forceful dilatation and esophagomyotomy in patients with achalasia of the esophagus (81)	Csendes *et al.*	147
72	Esophageal motility disorders in terms of pressure topography: the Chicago classification (82)	Kahrilas *et al.*	146
73	Four hundred laparoscopic myotomies for esophageal achalasia a single centre experience (83)	Zaninotto *et al.*	146
74	Application of topographical methods to clinical esophageal manometry (84)	Clouse *et al.*	145
75	The long-term efficacy of pneumatic dilatation and Heller myotomy for the treatment of achalasia (85)	Vela *et al.*	144
76	Diagnosis and management of achalasia (86)	Vaezi *et al.*	144
77	Outcomes of treatment for achalasia depend on manometric subtype (87)	Rohof *et al.*	142
78	Controlled trial of botulinum toxin injection versus placebo and pneumatic dilation in achalasia (88)	Annese *et al.*	142
79	Integrity of cholinergic innervation to the lower esophageal sphincter in achalasia (89)	Holloway *et al.*	141
80	Comparison of perioperative outcomes between peroral esophageal myotomy (poem) and laparoscopic Heller myotomy (90)	Hungness *et al.*	138
81	Lack of vasoactive intestinal polypeptide nerves in esophageal achalasia (91)	Aggestrup *et al.*	138
82	A comparative study on comprehensive, objective outcomes of laparoscopic Heller myotomy with per-oral endoscopic myotomy (poem) for achalasia (92)	Bhayani *et al.*	137
83	A multicentre randomised study of intrasphincteric botulinum toxin in patients with oesophageal achalasia (93)	Annese *et al.*	137

Table 1 *(continued)*

Table 1 *(continued)*

Rank	Title of article	Authors	Number of citations
84	Effect of sleep, spontaneous gastroesophageal reflux, and a meal on upper esophageal sphincter pressure in normal human volunteers (94)	Kahrilas *et al.*	137
85	Randomized controlled trial of laparoscopic Heller myotomy plus dor fundoplication versus Nissen fundoplication for achalasia long-term results (95)	Rebecchi *et al.*	136
86	Randomized controlled trial of botulinum toxin versus laparoscopic Heller myotomy for esophageal achalasia (96)	Zaninotto *et al.*	136
87	Role of nitric oxide in esophageal peristalsis in the opossum (97)	Yamato *et al.*	136
88	Timed barium oesophagram: better predictor of long-term success after pneumatic dilation in achalasia than symptom assessment (98)	Vaezi *et al.*	135
89	Long term results of pneumatic dilation in achalasia followed for more than 5 years (99)	West *et al.*	132
90	Sustained esophageal contraction: a marker of esophageal chest pain identified by intraluminal ultrasonography (100)	Balaban *et al.*	128
91	Long-term results of esophagomyotomy for achalasia of esophagus (101)	Jara *et al.*	128
92	Esophageal achalasia: laparoscopic versus conventional open Heller-dor operation (102)	Ancona *et al.*	127
93	Radionuclide transit studies in the detection of oesophageal dysmotility (103)	Blackwell *et al.*	127
94	Graded pneumatic dilation using rigiflex achalasia dilators in patients with primary esophageal achalasia (104)	Kadakia *et al.*	126
95	Pneumatic dilatation or esophagomyotomy treatment for idiopathic achalasia: clinical outcomes and cost analysis (105)	Parkman *et al.*	126
96	Esophageal spasm: clinical and manometric response to nitroglycerine and long acting nitrites (106)	Swamy *et al.*	126
97	Unexplained chest pain: the hypersensitive, hyperreactive, and poorly compliant esophagus (107)	Rao *et al.*	125
98	Per-oral endoscopic myotomy: a series of 500 patients (108)	Inoue *et al.*	123
99	Perioperative management and treatment for complications during and after peroral endoscopic myotomy (poem) for esophageal achalasia (ea) (data from 119 cases) (109)	Ren *et al.*	122
100	Contraction abnormalities of the esophageal body in patients referred to manometry: a new approach to manometric classification (110)	Clouse *et al.*	122

Table 2 Number of articles published per decade

Year	Number of papers
2011–2018	13
2001–2010	25
1991–2000	32
1981–1990	19
1971–1980	7
<1970	4

highest number of citations was "Peroral endoscopic myotomy (POEM) for esophageal achalasia" by Inoue *et al.*, receiving 665 citations (11).

The oldest manuscript featured in the top 100 list was by Merendino *et al.* ("The concept of sphincter substitution by an interposed jejunal segment for anatomic and physiologic abnormalities at the esophagogastric junction") and published in 1955 (48). "The Chicago classification of esophageal motility disorders, version 3.0" by Kahrilas *et al.* and "Per-oral endoscopic myotomy: a series of 500 patients" by Inoue *et al.* (17,108) were the most recent manuscripts, both published in 2015. *Table 2* lists the number of articles from the top 100 list published in each decade.

Table 3 Top 10 papers with the highest citation rate

Title of article	1st author	Year	Citation rate
The Chicago classification of esophageal motility disorders, v3.0	Kahrilas, Peter J	2015	13,067
Peroral endoscopic myotomy (POEM) for esophageal achalasia	Inoue, Haruhiro	2010	8,313
Chicago classification criteria of esophageal motility disorders defined in high resolution esophageal pressure topography	Bredenoord, Albert J, The International High Resolution Manometry Working Group	2012	6,867
Pneumatic dilation versus laparoscopic Heller's myotomy for idiopathic achalasia	Boeckxstaens, Guy E	2011	5,129
Per-oral endoscopic myotomy: a series of 500 patients	Inoue, Haruhiro	2015	4,100
Endoscopic and surgical treatments for achalasia: a systematic review and meta-analysis	Campos, Guilherme M	2009	3,878
Achalasia	Boeckxstaens, Guy E	2014	3,875
Achalasia: a new clinically relevant classification by high-resolution manometry	Pandolfino, John E	2008	3,780
A comparative study on comprehensive, objective outcomes of laparoscopic Heller myotomy with per-oral endoscopic myotomy (poem) for achalasia	Bhayani, Neil H	2014	3,425
Peroral endoscopic myotomy for the treatment of achalasia: a prospective single center study	von Renteln, Daniel	2012	3,417

To address the issue of historical bias, we calculated the citation rate of the manuscripts in the top 100 list. *Table 3* shows the top 10 papers with the highest citation rate. "The Chicago classification of esophageal motility disorders, version 3.0" by Kahrilas *et al.*, published in 2015, was the article with the highest citation rate (13,067 citations per year) (17).

The 100 most influential papers appeared in 26 journals (*Table 4*). The number of manuscripts per journal ranged from 1 to 32. The journal *Gastroenterology* featured the highest number of papers and accrued the highest total number of citations (32 articles and 6,675 citations respectively). Following that, *Annals of Surgery* had 12 manuscripts and 2,444 total citations and *Gut* had 10 manuscripts and 2,076 total citations. Endoscopy published the most cited paper in the top 100 list ["Peroral endoscopic myotomy (POEM) for esophageal achalasia" by Inoue *et al.*] (11).

The United States of America was the country that produced most publications, with 66 out of 100 articles, followed by Italy with 8 publications (*Table 5*). Belgium, Australia, and Germany had 4 publications each. Most manuscripts in the top 100 list originated from Northwestern University (13 manuscripts) (*Table 6*). Northwestern University was also the institution that accrued the highest total number of citations (3,238 citations). Showa University Northern Yokohama Hospital in Japan produced the most cited manuscript in the top 100 list ["Peroral endoscopic myotomy (POEM) for esophageal achalasia" by Inoue *et al.*] (11).

Table 7 lists all the authors that contributed to more than one manuscript, either as the 1st authors or as co-authors. Out of a total of 367 authors, 81 participated in the authorship of more than one publications featured in the top 100 list. Peter Kahrilas from Northwestern University was the most cited author (3,650 total citations), followed by Joel Richter from the University of South Florida (2,815 citations). Peter Kahrilas had 6 articles as the 1st author and 8 articles as co-author. Joel Richter had 4 articles as the 1st author and 10 articles as co-author.

Discussion

This bibliometric analysis is the first of its kind to study the most cited papers on the topic of esophageal motility disorders. The article with the highest total number of citations and second highest citation rate is the one entitled "Peroral endoscopic myotomy (POEM) for esophageal achalasia" and was performed by Inoue *et al.* from Showa University Northern Yokohama Hospital in Japan (11). This article was the first description of POEM, a technique developed by Inoue and his colleagues to treat esophageal achalasia with the use of endoscopic surgery. Their short-term outcomes were excellent opening the way towards less invasive permanent treatment methods for esophageal achalasia (11). This technique was widely accepted as an alternative to surgical myotomy, and some years later, Inoue

Table 4 Journals that published the top 100 papers

Journal	Number of articles	Total number of citations
Gastroenterology	32	6,675
Annals of Surgery	12	2,444
Gut	10	2,076
American Journal of Gastroenterology	9	1,502
Digestive Diseases and Sciences	4	887
Neurogastroenterology & Motility	4	1,113
Archives of Surgery	3	460
Annals of Internal Medicine	3	666
New England Journal of Medicine	3	965
Journal of Clinical Gastroenterology	2	322
Lancet	2	338
Endoscopy	2	916
Surgical Endoscopy	1	122
Journal of the American College of Surgeons	1	123
American Journal of Surgery	1	127
Journal of Gastrointestinal Surgery	1	138
Clinical Gastroenterology and Hepatology	1	144
American Journal of Physiology-Gastrointestinal and Liver Physiology	1	149
American Journal of Roentgenology	1	149
Journal of Clinical Investigation	1	159
Archives of Internal Medicine	1	172
American Journal of Surgical Pathology	1	187
Annals of Thoracic Surgery	1	191
Journal of the American Medical Association	1	198
European Journal of Clinical Investigation	1	226
European Journal of Nuclear Medicine	1	239

Table 5 Number of articles per country of origin in 100 most cited

Country	Number of articles	Total number of citations
USA	66	13,811
Italy	8	1,149
Australia	4	806
Belgium	4	939
Germany	4	880
Netherlands	3	686
Chile	2	483
Japan	2	788
Switzerland	2	355
UK	2	305
China	1	122
Spain	1	226
Sweden	1	138

et al. published a large series of 500 patients who underwent POEM at their institution confirming the safety and efficacy of this approach (108). The second most cited article is "Esophageal peristaltic dysfunction in peptic esophagitis" by Kahrilas *et al.* from the Northwestern University (12). In this article, the authors examined the association of reflux esophagitis with esophageal motility, reporting an increasing prevalence of peristaltic dysfunction with worsening esophagitis (12). In fact, abnormal peristalsis was identified in 25% of patients with mild esophagitis and 48% of patients with severe esophagitis (12). This was one of the first studies to show the association between the reflux of gastric acid and the disturbances in esophageal peristalsis, thus attracting much attention mainly due to the significant clinical implications of these findings (12).

Most papers in the top 100 list were published in more recent decades. Seventy [70] out of the 100 papers were published after 1990 and 57 of them were published between 1991–2010 (*Table 2*). Possible explanations for this trend could be the increased use of manometry in evaluating esophageal motility, as well as the introduction of novel therapeutic approaches, mainly for the treatment of achalasia.

Also, manuscripts published in recent years had generally higher citation rates and this may imply that these will accrue more citations and become even more influential within the next years (*Table 2*). The citation rate index for the most influential articles on esophageal motility disorders ranged from 34.17 to 130.67 (*Table 3*). The comparison with the citation rate index of other subjects shows that esophageal motility disorders accrue citations at a slower rate. For example, in a bibliometric analysis of the most

Table 6 Institutions with the highest number of papers in the top 100

Institution(s)	Number of manuscripts	Total number of citations
Northwestern University	13	3,238
The Cleveland Clinic Foundation	8	1,338
Wake Forest University School of Medicine	5	1,352
Catholic University of Leuven (KU Leuven), University Hospital Leuven	4	939
Washington University in St. Louis	4	723
Johns Hopkins University School of Medicine, Johns Hopkins Hospital	3	865
University of Amsterdam/ Academic Medical Center Amsterdam	3	686
Mayo Clinic	3	583
University of Washington	3	571
Medical College of Wisconsin	3	472
University of Padua (Università degli Studi di Padova)	3	428
Showa University Northern Yokohama Hospital	2	788
University of California, San Francisco	2	589
Royal Adelaide Hospital, Adelaide	2	484
University of Chile, Santiago	2	483
Vanderbilt University	2	454
National Naval Medical Center, Uniformed Services University of the Health Sciences	2	440
University Medical Center Hamburg-Eppendorf	2	361
University Hospital Zurich	2	355
The Oregon Clinic, Oregon Health & Sciences University	2	317
The Royal Infirmary of Edinburgh	2	305
Casa Sollievo della Sofferenza Hospital, Istituto di Ricovero e Cura a Carattere Scientifico (IRCSS-CSS), San Giovanni Rotondo	2	279
University of Pennsylvania	2	275
University of Iowa College of Medicine	2	274

Table 7 Authors that contributed to more than one manuscript in the top 100 list

Author	Citations	Total	1st author	Co-author
Kahrilas, PI	3,650	14	6	8
Richter, JE	2,815	14	4	10
Pandolfino, JE	2,327	10	4	6
Castell, DO	2,583	10		10
Vaezi, MF	1,018	6	5	1
Zaninotto, G	1,065	6	2	4
Dodds, WJ	1,551	6	1	5
Clouse, RE	941	5	4	1
Fox, MR	1,316	5	2	3
Annese, V	916	5	2	3
Bredenoord, AJ	1,320	5	1	4
Hogan, WJ	1,436	5		5
Costantini, M	910	5		5
Boeckxstaens, GE	788	4	2	2
Ghosh, SK	651	4	1	3
Smout, AJPM	1,305	4		4
Dent, J	684	4		4
Pasricha, PJ	903	3	3	
Inoue, H	993	3	2	1
Pellegrini, CA	614	3	1	2
Holloway, RH	546	3	1	2
Ancona, E	409	3	1	2
Wu, WC	1,014	3		3
Minami, H	993	3		3
Kalloo, AN	903	3		3
Arndorfer, RC	804	3		3
Dalton, Cb	747	3		3
Kwiatek, MA	731	3		3
Tack, J	661	3		3
Baker, ME	459	3		3
Andriulli, A	415	3		3
Eckardt, VF	519	2	2	
Csendes, A	483	2	2	
Benjamin, SB	440	2	2	

Table 7 *(continued)*

Table 7 *(continued)*

Author	Citations	Total	1st author	Co-author
Von Renteln, D	361	2	2	
Goldblum, JR	350	2	2	
Blackwell, JN	566	2	1	1
Spechler, SJ	564	2	1	1
Rohof, WO	501	2	1	1
Vantrappen, G	407	2	1	1
Cook, IJ	322	2	1	1
Bhayani, NH	317	2	1	1
Swanstrom, LL	317	2	1	1
Vela, MF	314	2	1	1
Bonavina, L	292	2	1	1
Kobayashi, Y	788	2		2
Kudo, S	788	2		2
Hendrix, TR	652	2		2
Ravich, WJ	652	2		2
Castell, JA	639	2		2
Schwizer, W	564	2		2
Bernhard, G	519	2		2
Busch, OR	501	2		2
Chaussade, S	501	2		2
Des Varannes, SB	501	2		2
Elizalde, JI	501	2		2
Gaudric, M	501	2		2
Braghetto, I	483	2		2
Henriquez, A	483	2		2
Lustman, PJ	456	2		2
Way, LW	447	2		2
Janssens, J	425	2		2
Shearman, DJC	400	2		2
Orringer, MB	394	2		2
Fuchs, KH	361	2		2
Kersten, JF	361	2		2
Rosch, T	361	2		2
Werner, YB	361	2		2
Clarke, JO	353	2		2
Rice, J	353	2		2
Dunst, CM	317	2		2
Kurian, AA	317	2		2
Rieder, E	317	2		2
Sharata, A	317	2		2
Rice, TW	307	2		2
Heading, RC	305	2		2
Peracchia, A	292	2		2
Battaglia, G	282	2		2
D'onofrio, V	273	2		2
Gatto, G	273	2		2
Staiano, A	267	2		2

Table 7 *(continued)*

Table 7 *(continued)*

influential papers on esophageal cancer by Powell *et al.*, the citation rate index ranged from 69 to 227 (9). "The Chicago classification of esophageal motility disorders, version 3.0" by Kahrilas *et al.* is the article with the highest citation rate and was published in 2015 (17). The Chicago Classification system uses HRM to categorize esophageal motility disorders and all versions of this system are featured in the top 100 list.

The majority of manuscripts were published in the journal *Gastroenterology*, followed by *Annals of Surgery* and *Gut*. Most manuscripts were published in journals in the field of gastroenterology (56 articles), as opposed to manuscripts published in surgery journals (21) and general and internal medicine journals (12). Accordingly, the majority of the manuscripts with the highest number of citations or the highest citation rate were published in gastroenterology journals (*Tables 1*,*3*).

Out of the 367 authors, 12 had more than 1,000 citations and only 4 had more than 2,000 citations. The most cited author was Peter Kahrilas from Northwestern University, followed by Joel Richter from the University of South Florida. The third and fourth most cited authors were Donald Castell from the Medical University of South Carolina and John Pandolfino from Northwestern University. These four authors were also the most published ones in

terms of publication volume. Kahrilas and Richter authored 14 manuscripts each, whereas Castell and Pandolfino authored 10 manuscripts each.

The main limitation of this study is that some types of bias might have impacted the results. Self-citation, powerful person bias, institutional bias or geographical bias may have caused disproportionate number of citations. Language bias may also be present, mainly because the search was limited to manuscripts only in the English language. Another issue that has to be taken into consideration is the possibility of historical bias; older publications often have a higher number of citations because they accumulated citations over many years, regardless of their scientific impact. We tried to address this issue by calculating the citation rate of the articles, in addition to their citation number. Nevertheless, the scientific impact of an article may be underestimated or overestimated with this study format. On the one hand, articles need a certain lead-time to start receiving citations. On the other hand, the likelihood of receiving citations rises with the increasing numbers of articles being published in peer-reviewed journals.

This citation analysis is the first to examine the most cited papers on the disorders of esophageal motility and can serve as a reference on the manuscripts, authors, and institutions that defined our understanding of the subject. Researchers and clinicians can also use this analysis to examine what are the key characteristics of citable articles. Finally, by studying the most impactful papers, researchers can determine the future directions in the research on esophageal motility disorders.

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Footnote

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