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Original Contribution

Bibliometric analysis of top 100 most-cited clinical studies on ultrasound in the Emergency Department

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ABSTRACT

Study objective: We identify and characterize the most highly cited articles related to ultrasonographic evaluations occurring in the emergency department.
Method: We retrieved the top 100 articles in terms of citations pertaining to ultrasonographic evaluations in the emergency department from the Scopus database. We determined the number of citations of each article, the number of citations per year, the number of Google Scholar citations, the ultrasonographical study fields, the number of patients evaluated in each study, and the specialties of the researchers conducting the studies and ultrasonographies. We then used the ANOVA test to compare the multivariate groups.
Results: The median citation number of the articles in the Scopus database was 115 (range: 75–681), and the number of citations per year was 7.5 (range: 3.8–40.1). Focused assessment with sonography in trauma and non-traumatic abdominal ultrasonography were conducted in 32 and 13 studies, respectively. The primary authors were emergency medicine specialists in 46 studies. We found that vascular and lung ultrasonography studies were characterized by the largest number of citations per year.
Conclusion: The most frequently cited studies conducted in the emergency department pertaining to the use of ultrasonography included a wide range of topics, and approximately half of the primary authors of these studies were emergency medicine specialists.

1. Introduction

Since the 1940s, when medical ultrasonographic systems were first developed, ultrasonography has been widely used in many medical specialties [1]. It has become a routine part of emergency care in recent years. Ultrasonographic imaging in the emergency department has been extended beyond tissue-based classical imaging procedures to create sonographical applications for specialized clinical referrals (e.g., focused abdominal sonography for trauma [FAST], shock protocols, and interventional procedures).

The growing number of publications on emergency ultrasonography in the last 20 years has contributed to the development of specialized emergency ultrasonographic imaging procedures [2]. However, the number of ultrasonography studies among the most-cited papers is less than expected [3,4]. No previous bibliographic study has evaluated publications on sonography in emergency medicine. In this study, we aimed to identify the most-cited articles involving ultrasonographic evaluations in the emergency department and to describe the characteristics of these studies.

2. Method

We carried out a bibliographic, descriptive analytical study. On January 1, 2016, to identify studies of emergency ultrasonography published in the international literature, the keywords "ultrasound and emergency" OR "ultrasonography and emergency" OR "sonography and emergency" were used as search terms in an advanced search of Scopus. The subject area was limited to medicine and human studies. The resultant publications were sorted based on the number of citations, and they were evaluated. Studies that focused on the use of ultrasound (US) in patient management for an emergency clinical situation or those where US was used as an imaging technique in the emergency department or in the prehospital setting were included in the study. Meta-analyses, reviews, and letters to the editors or studies that were conducted outside the emergency department or before referral to a hospital were excluded from the study.

After excluding 341 reviews and 57 conference papers, the abstracts of 522 articles were evaluated by two emergency medicine specialists to

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Table 1
The 100 most-cited clinical studies on ultrasound in the emergency department, ranked by citation frequency

Number	ARTICLE	Year	Authors	Scopus (total cite)	Citations per year	Google (total cite)
1	Non-invasive diagnosis of venous thromboembolism in outpatients. Lancet. 16;353(9148):190–5.	1999	Perrier A, Desmarais S, Miron MJ, et al.	681	40.1	877
2	Prospective evaluation of surgeons'use of ultrasound in the evaluation of trauma patients. J Trauma. 34(4):516–26*	1993	Rozycki GS, Ochsner MG, Jaffin JH et al.	254	11	356
3	Diagnosis of pulmonary embolism by a decision analysis-based strategy including clinical probability, D-dimer levels, and ultrasonography: a management study. Arch Intern Med. 11;156(5):531–6.**	1996	Perrier A, Bounameaux H, Morabia A, et al.	249	12.5	299
4	A prospective study of surgeon-performed ultrasound as the primary adjuvant modality for injured patient assessment. J Trauma. Sep.;39(3):492–8	1995	Rozycki GS, Ochsner MG, Schmidt JA, et al.	241	11.5	374
5	Hand-held thoracic sonography for detecting post-traumatic pneumothoraces: the Extended Focused Assessment with Sonography for Trauma (EFAST). J Trauma. 57(2):288–95.	2004	Kirkpatrick AW, Sirois M, Laupland KB, et al.	226	18.8	374
6	Surgeon-performed ultrasound for the assessment of truncal injuries: lessons learned from 1540 patients. Ann Surg 228(4):557–67.	1998	Rozycki GS, Ballard RB, Feliciano DV, et al.	223	11.2	226
7	Prospective analysis of a rapid trauma ultrasound examination performed by emergency physicians. J Trauma. 38(6):879–85.	1995	Ma OJ, Mateer JR, Ogata M, et al.	220	10.5	341
8	Ultrasound in blunt abdominal and thoracic trauma. J Trauma 34(4):488–95.	1993	Röthlin MA, Näf R, Amgwerd M, et al.	207	7.5	116
9	A prospective comparison of supine chest radiography and bedside ultrasound for the diagnosis of traumatic pneumothorax. Acad Emerg Med 12(9):844–9.	2005	Blaivas M, Matthew L, Sandeep D.	206	18.7	330
10	Diagnosis of pulmonary embolism by multidetector CT alone or combined with venous ultrasonography of the leg: a randomized non-inferiority trial. Lancet 19;371(9621):1343–52.	2008	Righini M, Le Gal G, Aujesky D, et al.	204	25.5	291
11	Ultrasonography and limited computed tomography in the diagnosis and management of appendicitis in children. JAMA 15;282(11):1041–6.	1999	Garcia Peña BM1, Mandl KD, Kraus SJ, et al.	202	10.6	246
12	Blunt abdominal trauma in cases of multiple trauma evaluated by ultrasonography: a prospective analysis of 291 patients. J Trauma. 32(4):452–8.	1992	Hoffmann R, Nerlich M, Muggia-Sullam M, et al.	199	8.3	272
13	Traumatic pneumothorax detection with thoracic US: correlation with chest radiography and CT-initial experience. Radiology. 225(1):210–4.	2002	Rowan KR, Kirkpatrick AW, Liu D, et al.	185	13.2	269
14	1000 consecutive ultrasounds for blunt abdominal trauma. J Trauma 40(4):607–10.	1996	McKenney MG, Martin L, Lentz K, et al.	178	8.9	268
15	Sonography in blunt abdominal trauma: a preliminary progress report. J Trauma 33(1):39–43	1992	Tso P, Rodriguez A, Cooper C, et al.,	174	7.3	274
16	Prospective comparison of diagnostic peritoneal lavage, computed tomographic scanning, and ultrasonography for the diagnosis of blunt abdominal trauma. J Trauma 35(2):267–70.	1993	Liu M, Lee CH, P'eng FK.	172	7.2	172
17	Occult traumatic pneumothorax: diagnostic accuracy of lung ultrasonography in the emergency department. Chest133(1):204–11	2008	Soldati G, Testa A, Sher S, et al.	163	20.4	253
18	Real-time ultrasonographically-guided internal jugular vein catheterization in the emergency department increases success rates and reduces complications: a randomized, prospective study. Ann Emerg Med 48(5):540–7.	2006	Leung J, Duffy M, Finckh A.	161	16.1	226
19	Computed tomography and ultrasonography do not improve and may delay the diagnosis and treatment of acute appendicitis. Arch Surg 136(5):556–62.	2001	Lee SL, Walsh AJ, Ho HS.	159	11.9	279
20	Ultrasonography-guided peripheral intravenous access versus traditional approaches in patients with difficult intravenous access. Ann Emerg Med 46(5):456–61.	2005	Costantino TG, Parikh AK, Satz WA, et al.	158	14	137
21	Focused abdominal sonogram for trauma: the learning curve of nonradiologist clinicians in detecting hemoperitoneum. J Trauma 46(4):553–62	1999	Shackford SR, Rogers FB, Osler TM, et al.	158	9.1	210
22	Emergency center ultrasonography in the evaluation of hemoperitoneum: a prospective study. J Trauma Jan.;31(1):20–3.	1991	Kimura A, Otsuka T.	158	6.3	228
23	Determination of left ventricular function by emergency physician echocardiography of hypotensive patients. Acad Emerg Med 9(3):186–93.	2002	Moore CL, Rose GA, Tayal VS, et al.	157	12.4	338
24	Randomized, controlled clinical trial of point-of-care limited ultrasonography assistance of central venous cannulation: the Third Sonography Outcomes Assessment Program (SOAP-3) Trial. Crit Care Med 33(8):1764–9.	2005	Milling TJ Jr., Rose J, Briggs WM, et al.	156	14.2	248
25	Abdominal injuries without hemoperitoneum: a potential limitation of focused abdominal sonography for trauma (FAST). J Trauma 42(4):617–23	1997	Chiu WC, Cushing BM, Rodriguez A, et al.	155	8.2	225
26	The role of ultrasound in patients with possible penetrating cardiac wounds: a prospective multicenter study. J Trauma 46(4):543–51.	1999	Rozycki GS, Feliciano DV, Ochsner MG, et al.	154	9.1	280
27	Randomized, controlled trial of immediate versus delayed goal-directed ultrasound to identify the cause of nontraumatic hypotension in emergency department patients. Crit Care Med 32(8):1703–8.	2004	Jones AE, Tayal VS, Sullivan DM, et al.	146	12.2	233
28	Nonenhanced helical CT and US in the emergency evaluation of patients with renal colic: prospective comparison. Radiology 217(3):792–7.	2000	Sheafor DH, Hertzberg BS, Freed KS, et al.	146	9.3	222
29	Can ultrasound replace diagnostic peritoneal lavage in the assessment	1994	McKenney M, Lentz K,	145	6.6	216

(continued on next page)

Table 1 *(continued)*

Number	ARTICLE	Year	Authors	Scopus (total cite)	Citations per year	Google (total cite)
	of blunt trauma? J Trauma 37(3):439–41		Nunez D, et al.			
30	Bedside lung ultrasound in the assessment of alveolar-interstitial syndrome. Am J Emerg Med. 24(6):689–96.	2006	Volpicelli G, Mussa A, Garofalo G, et al.	143	14.3	208
31	Ultrasound guidance versus the landmark technique for the placement of central venous catheters in the emergency department. Acad Emerg Med 9(8):800–5.	2002	Miller AH, Roth BA, Mills TJ, et al.	140	10	219
32	Ultrasound-guided brachial and basilic vein cannulation in emergency department patients with difficult intravenous access. Ann Emerg Med 34(6):711–4.	1999	Keyes LE, Frazee BW, Snoey ER, et al.	134	7.9	198
33	Outcome in cardiac arrest patients found to have cardiac standstill on the bedside emergency department echocardiogram. Acad Emerg Med 8(6):616–21.	2001	Blaivas M, Fox JC.	130	9.2	164
34	Prompt diagnosis of ectopic pregnancy in an emergency department setting. Obstet Gynecol 84(6):1010–5.	1994	Barnhart K, Mennuti MT, Benjamin I, et al.	130	5.9	168
35	Quantitative sensitivity of ultrasound in detecting free intraperitoneal fluid. J Trauma 39(2):375–80.	1995	Branney SW, Wolfe RE, Moore EE, et al.	128	6.1	172
36	Suspected appendicitis in children: US and CT–a prospective randomized study. Radiology 223(3):633–8.	2002	Kaiser S, Frenckner B, Jorulf HK.	127	9.1	213
37	2576 ultrasounds for blunt abdominal trauma. J Trauma 50(1):108–12.	2001	Dolich MO, McKenney MG, Varela JE, et al.	125	8.3	194
38	Sonography in a clinical algorithm for early evaluation of 1671 patients with blunt abdominal trauma. AJR Am J Roentgenol 172(4):905–11.	1999	Bode PJ, Edwards MJ, Kruit MC, et al.	125	7.3	187
39	The role of ultrasonography in blunt abdominal trauma: results in 250 consecutive cases. J Trauma 36(2):178–81.	1994	Goletti O, Ghiselli G, Lippolis PV, et al.	125	5.6	123
40	Abdominal ultrasound as a reliable indicator for conclusive laparotomy in blunt abdominal trauma. J Trauma 34(1):27–31.	1993	Bode PJ, Niezen RA, van Vugt AB, et al.	125	5.4	167
41	A prospective evaluation of abdominal ultrasound in blunt trauma: is it useful? J Trauma Jun.;40(6):875–83	1996	Healey MA, Simons RK, Winchell RJ, et al.	124	6.2	125
42	Emergent abdominal sonography as a screening test in a new diagnostic algorithm for blunt trauma. J Trauma 40(6):867–74.	1996	Boulanger BR, McLellan BA, Brenneman FD, et al.	123	6.2	193
43	Evaluation of acute scrotum in the emergency department. J Pediatr Surg30(2):277–81	1995	Lewis AG, Bukowski TP, Jarvis PD, et al.	122	5.8	212
44	Ultrasound training for emergency physicians—a prospective study. Acad Emerg Med 7(9):1008–14.	2000	Mandavia DP, Aragona J, Chan L, et al.	120	7.5	113
45	Sonographic evaluation of ovarian torsion in childhood and adolescence. AJR Am J Roentgenol 150(3):647–9.	1988	Graif, M, Itzchak Y.	120	4.1	198
46	Correlation of optic nerve sheath diameter with direct measurement of intracranial pressure. Acad Emerg Med 15(2):201–4.	2008	Kimberly HH, Shah S, Marill K, et al.	119	14.9	201
47	Accuracy of emergency physician assessment of left ventricular ejection fraction and central venous pressure using echocardiography. Acad Emerg Med 10(9):973–7.	2003	Randazzo MR, Snoey ER, Levitt MA, et al.	119	8.7	189
48	Elevated intracranial pressure detected by bedside emergency ultrasonography of the optic nerve sheath. Acad Emerg Med 10(4):376–81.	2003	Blaivas, M, Theodoro, D, Sierzenski, PR.	117	12	111
49	Ultrasound evaluation of blunt abdominal trauma: program implementation, initial experience, and learning curve. J Trauma 42(3):384–8	1997	Thomas B, Falcone RE, Vasquez D, et al.	117	6	174
50	A prospective trial of computed tomography and ultrasonography for diagnosing appendicitis in the atypical patient. Am J Surg 179(5):379–81.	2000	Horton MD, Counter SF, Florence MG, et al.	115	7.5	249
51	Usefulness and limitations of ultrasonography in the initial evaluation of blunt abdominal trauma. J Trauma 45(1):45–50	1998	Yoshii H, Sato M, Yamamoto S, et al.	115	6.1	150
52	Acute appendicitis: MR imaging and sonographic correlation. AJR. American journal of roentgenology 168(3), 669–674.	1997	Incesu L, Coskun A, Selcuk MB, et al.	113	6.2	174
53	Emergency department sonographic measurement of optic nerve sheath diameter to detect findings of increased intracranial pressure in adult head injury patients. Ann Emerg Med 49(4):508–14.	2007	Tayal VS, Neulander M, Norton HJ, et al.	111	12.3	206
54	Bedside echocardiography by emergency physicians. Ann Emerg Med 38(4):377–82.	2001	Mandavia DP, Hoffner RJ, Mahaney K, et al.	109	7.3	176
55	Randomized controlled clinical trial of point-of-care, limited ultrasonography for trauma in the emergency department: the first sonography outcomes assessment program trial. Ann Emerg Med 48(3):227–35.	2006	Melniker LA, Leibner E, McKenney MG, et al.	107	10.7	183
56	Diagnostic accuracy of ultrasound above and below the beta-hCG discriminatory zone. Obstetrics & Gynecology 94(4), 583–587.	1999	Barnhart KT, Simhan H, Kamelle SA	106	6.4	108
57	Ultrasound based key clinical pathway reduces the use of hospital resources for the evaluation of blunt abdominal trauma. J Trauma 42(6):1086–90.	1997	Branney SW, Moore EE, Cantrill SV, et al.	105	5.9	124
58	Rapid detection of pneumothorax by ultrasonography in patients with multiple trauma. Crit Care 10(4):R112.	2006	Zhang M, Liu ZH, Yang JX, Gan JX, et al.	104	10.4	179
59	The value of physical examination in the diagnosis of patients with blunt abdominal trauma: a retrospective study. Injury 28(4), 261–265.	1997	Schurink GW, Bode PJ, van Luijt PA, et al.	104	5.5	161
60	Sonographic measurement of the inferior vena cava as a marker	2005	Lyon, M, Fvas M, Brannam, L.	101	9.2	153

Table 1 *(continued)*

Number	ARTICLE	Year	Authors	Scopus (total cite)	Citations per year	Google (total cite)
	of blood loss. Am J Emerg Med 23(1):45–50.					
61	Serial 2-point ultrasonography plus D-dimer vs whole-leg color-coded Doppler ultrasonography for diagnosing suspected symptomatic deep vein thrombosis: A randomized controlled trial. JAMA 8;300(14):1653–9	2008	Bernardi E, Camporese G, Büller HR et al.	100	12.5	154
62	Use of ultrasonography in the patient with acute abdominal trauma. J Ultrasound Med 16(10):653–62	1997	McGahan JP, Rose J, Coates TL, et al.	100	5.3	144
63	Real-Time Ultrasound–Guided Femoral Vein Catheterization During Cardiopulmonary Resuscitation. Ann Emerg Med 29(3):331–6	1997	Hilty WM, Hudson PA, Levitt MA, et al.	100	5.1	122
64	The role of surgeon-performed ultrasound in patients with possible cardiac wounds. Ann Surg. 1996 Jun.;223(6):737–44	1996	Rozycki GS, Feliciano DV, Schmidt JA, et al.	100	5.9	140
65	Imaging evaluation of suspected appendicitis in a pediatric population: effectiveness of sonography versus CT. AJR Am J Roentgenol 175(4):977–80.	2000	Sivit CJ, Applegate KE, Stallion A, et al.	98	6.1	134
66	Emergency department ultrasound scanning for abdominal aortic aneurysm: accessible, accurate, and advantageous. Ann Emerg Med 36(3):219–23.	2000	Kuhn M, Bonnin RL, Davey MJ, et al.	98	6.4	160
67	Hypotension after blunt abdominal trauma: the role of emergent abdominal sonography in surgical triage. J Trauma 41(5):815–20.	1996	Wherrett LJ, Boulanger BR, McLellan BA, et al.	98	4.9	159
68	Ectopic pregnancy: prospective study with improved diagnostic accuracy. Ann Emerg Med 28(1):10–7.	1996	Kaplan BC, Dart RG, Moskos M, et al.	98	4.9	157
69	Sonographic screening of mass casualties for abdominal and renal injuries following the 1988 Armenian earthquake. J trauma 31(2), 247–250.	1991	Sarkisian AE, Khondkarian RA, Amirbekian NM, et al.	96	4.6	110
70	Emergency department ultrasound in the evaluation of blunt abdominal trauma. Am J Emerg Med 11(4):342–6.	1993	Jehle, D, Guarino J, Karamanoukian H.	96	4.2	143
71	Using clinical evaluation and lung scan to rule out suspected pulmonary embolism: is it a valid option in patients with normal results of lower-limb venous compression ultrasonography? Arch Intern Med 28;160(4):512–6.	2000	Perrier A, Miron MJ, Desmarais S, et al.	95	5.5	148
72	Prehospital ultrasound imaging improves management of abdominal trauma. Br J Surg 93(2):238–42.	2006	Walcher F, Weinlich M, Conrad G, et al.	94	9.4	161
73	Emergency echocardiography to detect pericardial effusion in patients in PEA and near-PEA states. Resuscitation 59(3), 315–318.	2003	Tayal VS, Kline JA.	93	6.2	189
74	Ultrasonography for the evaluation of hemoperitoneum during resuscitation: A simple scoring system. J Trauma 36(2):173–7	1994	Huang MS, Liu M, Wu JK, et al.	93	4.2	125
75	Sonography compared with radiography in revealing acute rib fracture. AJR Am J Roentgenol 173(6):1603–9	1999	Griffith JF, Rainer TH, Ching AS, et al.	92	5.4	137
76	Trauma ultrasound examination versus chest radiography in the detection of hemothorax. Ann Emerg Med 29(3):312–5	1997	Ma OJ, Mateer JR.	91	4.7	158
77	Suspected ureteral colic: primary helical CT versus selective helical CT after unenhanced radiography and sonography. AJR Am J Roentgenol 178(2):379–87.	2002	Catalano O, Nunziata A, Altei F, Siani A.	89	6.4	147
78	Can cardiac sonography and capnography be used independently and in combination to predict resuscitation outcomes? Acad Emerg Med 8(6):610–5.	2001	Salen P, O'Connor R, Sierzenski P, Passarello B, et al.	89	5.9	111
79	A study of bedside ocular ultrasonography in the emergency department. Acad Emerg Med 9(8):791–9.	2002	Blaivas M, Theodoro D, Sierzenski PR.	88	7.5	217
80	A prospective study of ultrasonography in the ED by emergency physicians. Am J Emerg Med 12(2):185–9.	1994	Schlager D, Lazzareschi G, Whitten D, et al.	87	4.0	136
81	Rapid detection of traumatic effusion using surgeon-performed ultrasonography. J Trauma 44(2):291–6	1998	Sisley AC, Rozycki GS, Ballard RB, et al.	87	4.8	168
82	Does the presence or absence of sonographically identified cardiac activity predict resuscitation outcomes of cardiac arrest patients? Am J Emerg Med 23(4):459–62	2005	Salen P, Melniker L, Chooljian C, et al.	86	7.8	123
83	Emergency department bedside ultrasonographic measurement of the caval index for noninvasive determination of low central venous pressure. Ann Emerg Med 55(3):290–5	2010	Nagdev AD, Merchant RC, Tirado-Gonzalez A, et al.	84	14.4	251
84	Emergency Thoracic Ultrasound in the Differentiation of the Etiology of Shortness of Breath (ETUDES): Sonographic B-lines and N-terminal Pro-brain-type Natriuretic Peptide in Diagnosing Congestive Heart Failure. Acad Emerg Med 16(3):201–10.	2009	Liteplo AS, Marill KA, Villen T, et al.	84	9	207
85	Acute appendicitis in children: comparison of clinical diagnosis with ultrasound and CT imaging. Pediatr Radiol. 30(2):94–8.	2000	Karakas SP, Guelfguat M, Leonidas JC, et al.	83	5.7	169
86	The effect of soft-tissue ultrasound on the management of cellulitis in the emergency department. Acad Emerg Med 13(4):384–8.	2006	Tayal VS, Hasan N, Norton HJ, et al.	82	8.2	130
87	Sonography as the primary screening technique for blunt abdominal trauma: experience with 899 patients. AJR Am J Roentgenol. 170(4):979–85.	1998	McKenney KL, Nunez Jr. DB, McKenney MG, et al.	82	3.8	152
88	Lower Extremity Doppler for Deep Venous Thrombosis–Can Emergency Physicians Be Accurate and Fast? Acad Emerg Med 7(2):120–6.	2000	Blaivas M, Lambert MJ, Harwood RA, et al.	81	5.1	126
89	Chest ultrasonography in lung contusion. Chest 130(2):533–8.	2006	Soldati G, Testa A, Silva FR, et al.	80	8	141
90	Comparison of CT and sonography in the diagnosis of acute appendicitis: a blinded prospective study. AJR Am J Roentgenol 181(5):1355–9.	2003	Poortman P, Lohle PN, Schoemaker CM, et al.	80	6.2	142
91	Chest ultrasonography for the diagnosis and monitoring of high-altitude pulmonary edema. Chest 131(4):1013–8.	2007	Fagenholz PJ, Gutman JA, Murray AF, et al.	79	8.7	110
92	Focused echocardiographic evaluation in life support and peri-resuscitation of emergency patients: a prospective trial. Resuscitation 81(11):1527–33.	2010	Breitkreutz R, Price S, Steiger HV, et al.	78	13	112

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Table 1 *(continued)*

Number	ARTICLE	Year	Authors	Scopus (total cite)	Citations per year	Google (total cite)
93	ABSCESS: applied bedside sonography for convenient evaluation of superficial soft tissue infections. Acad Emerg Med 12(7):601–6.	2005	Squire BT, Fox JC, Anderson C.	78	7.1	122
94	Emergency Nurses' Utilization of Ultrasound Guidance for Placement of Peripheral Intravenous Lines in Difficult-access Patients. Acad Emerg Med 11(12):1361–3.	2004	Brannam L, Blaivas M, Lyon M, et al.	77	6.2	153
95	Comparative assessment of CT and sonographic techniques for appendiceal imaging. AJR Am J Roentgenol 176(4):933–41.	2001	Wise SW, Labuski MR, Kasales CJ, et al.	77	5.3	153
96	Prospective evidence of the superiority of a sonography-based algorithm in the assessment of blunt abdominal injury. J Trauma 47(4):632–7.	1999	Boulanger BR, McLellan BA, Brenneman FD, et al.	76	4.5	123
97	Bedside ultrasound of the lung for the monitoring of acute decompensated heart failure. Am J Emerg Med 26(5):585–91.	2008	Volpicelli G, Caramello V, Cardinale L, et al.	75	9.4	100
98	Use of ultrasonography for the diagnosis of testicular injuries in blunt scrotal trauma. J Urol 175(1):175–8	2006	Buckley JC, McAninch JW	75	9	267
99	Prospective study of accuracy and outcome of emergency ultrasound for abdominal aortic aneurysm over two years. Acad Emerg Med 10(8):867–71	2003	Tayal VS, Graf CD, Gibbs MA.	75	5.8	107
100	An algorithm to reduce the incidence of false-negative FAST examinations in patients at high risk for occult injury. J Am Coll Surg 189(2):145–50	1999	Ballard RB, Rozycki GS, Newman PG, et al.	75	4.4	102

* The Journal of Trauma Injury Infection and Critical Care (J Trauma) has continued by Journal of Trauna and Acute Care Surgery since 2011.
** Archives of Internal Medicine (Arch Intern Med)has continued by JAMA Internal Medicine since 2012.

determine the 100 most-cited studies that best matched the inclusion criteria. In cases of disagreement between the specialists, a third specialist conducted an evaluation and rendered the deciding alternative. The chosen articles were sorted according to the number of citations as reported by Scopus. The annual citation rate was calculated by dividing the total number of citations by the number of years since publication (citations per year = total number of citations/[2016-publication year]). The number of citations obtained from each study was also evaluated using the Google Scholar database in addition to the Scopus data base.

Studies were modified using the methods of Lim et al. and evaluated by two independent emergency medicine specialists [5]. Randomized controlled studies, case series, and cohort studies were included. The primary authors' areas of specialty were determined based on affiliation, as reported in the journal. The number of patients evaluated in each study and the countries in which the studies were conducted (the primary author's country was used in international studies) were determined and recorded. Those performing the USs were classified as (1) emergency physician, (2) surgeon, (3) radiologist, (4) other (nurse, technician, etc.), or (5) not applicable (N/A). Using categories from the Web of Science (WOS), the journals in which the articles were published were classified as (1) surgery, (2) emergency medicine, (3) radiology, or (4) other. Publication dates were classified as (1) prior to 1990, (2) 1990 to 1994, (3) 1995 to 1999, (4) 2000 to 2004, (5) 2005 to 2009, or (6) 2010 or later. The numbers of patients were classified as (1) less than 100, (2) 101 to 500, (3) 501 to 1000, or (4) more than 1000.

Ethical approval was obtained from the Ethics Committee of the Dokuz Eylul University School of Medicine.

Data were evaluated online and recorded on study data forms. Statistical analysis was performed using SPSS 15.0 for Windows. Categorical variables were described using numbers and percentages, whereas continuous variables were described using median and range. Numerical variables between two independent groups were compared using the Student *t* test, whereas categorical variables were compared using the chi-square test. Multivariate groups were compared using analysis of variance. Statistical significance was recognized when $P < .05$.

3. Results

The 100 most-cited clinical studies on US in emergency departments are listed in rank order in Table 1. Published between 1988 and 2010, 85 were of prospective cohort design, 9 were randomized controlled studies, and 6 were retrospective studies. All were written in English and published in one of 21 journals, 35 in emergency medicine journals, 34 in surgical journals, 14 in radiology journals, and 5 in critical care journals. Those journals that published more than five articles is given in Table 2. The median number of authors was 6 (range, 1–21).

Using Scopus to determine the number of citations, the median was 115 (range, 75–681), but using Google Scholar, the median was 170.5 (range, 100–877). The difference between them was significant ($P < .001$). The most-cited study in all three categories was described by Perrier et al. in "Non-invasive diagnosis of venous thromboembolism in outpatients.".

Using the annual citation rate to determine the top 10 articles, 5 were published in emergency medicine journals. Three were on the topic of lung US, 2 were regarding interventional US, 2 were on the vascular US and the remainder involved FAST exams, inferior vena cava (IVC) and optic nerve US. Three were randomized controlled studies, and 7 were prospective cohort studies.

In all, 37,211 patients were studied (median per study, 214.5; range, 11–2676). There was no difference between the number of patients evaluated in the studies and total citations ($P = .103$; Table 3).

The primary authors were most commonly emergency physicians (46%) and surgeons (32%). The most commonly researched areas were FAST and abdominal US (32% and 13%, respectively). There was no significant relationship between US area and number of citations, per Scopus ($P = .472$). However, there was a significant difference when the annual citation rate was used ($P = .025$). Vascular US studies had the greatest median annual citation rate (12.5; range, 5.1–40.1). The people performing the USs were most commonly emergency physicians (37) and radiologists (20); however, we could not obtain this information in 6 studies.

The subjects of the studies according to primary author affiliation are presented in Table 2. Emergency physicians conducted studies on a variety of subjects, while surgeons and radiologists studied mostly FAST and abdominal USs (Fig. 1).

Table 2
Journals with more than five published articles from the 100 most-cited clinical studies on ultrasound in the emergency department

Journal title	Number of articles
Journal of Trauma and Acute Care Surgery	27
Academic Emergency Medicine	16
Annals of Emergency Medicine	11
American Journal of Roentgenology	8
American Journal of Emergency Medicine	6

Table 3
Properties of the 100 most-cited studies on ultrasound conducted in the emergency department

	Subgroup	*N*	Total citations Median(range)	Annual citations Median (range)	Total citations *P* value	Annual citations *P* value
Sample size	≤100	25	100 (75–185)	7.5 (4.2–14.4)	0.103	0.51
	101–500	54	118 (75–254)	7.4 (3.8–20.4)		
	501–1000	11	124 (76–681)	8.2 (4.5–40.1)		
	>1000	10	125.5(75–223)	6.0 (4.4–12.5)		
	Total	100	115 (75–681)	7.5 (3.8–40.1)		
Year of publication	<1990	1	120	4.3	0.330	0.005*
	1990–1994	15	130 (87–254)	5.9 (4–11)		
	1995–1999	32	116 (75–681)	6.2 (4.0–40.1)		
	2000–2004	29	109 (75–226)	7.5 (4.7–18.8)		
	2005–2009	21	104 (75–206)	10.5 (3.8–25.5)		
	≥2010	2	78–84	132.0–14.4		
USG area	FAST	32	124.5 (75–254)	7.2 (4.2–8.8)	0.472	0.025*
	Abdomen (non trauma)	13	120 (77–222)	6.1 (4.3–11.9)		
	Cardiac	11	100 (75–157)	8.7 (4.8–13)		
	Lung	10	97.5 (79–206)	9.7 (4.0–20.4)		
	Vascular	8	129 (75–681)	12.5 (5.1–40.1)		
	Invasive	7	120 (77–156)	8,1 (5.3–14.2)		
	Optic nerve	4	114 (88–119)	11.2 (7.5–12.3)		
	Urogenital	4	105.5 (75–146)	7.4 (4.7–9.3)		
	Goal directed	3	103.5 (87–120)	4.6 (4–5.2)		
	Obstetric	3	106 (98–130)	6,4 (5.9–6.4)		
	IVC	2	87–120	9.2–14.4		
	Soft tissue	2	78–82	3.8–7.1		
	Bone	1	92	5.4		
Country	USA	69	109 (75–254)	7.5 (3.8–18.7)	0.156	0.210
	Non USA articles	31	123 (75–691)	7.2 (4.2–40.0)		
	Italy	8				
	Switzerland	5				
	Canada, Holland	3				
	Germany, China, Japan	2				
	Australia, Armenia, Israel, Sweden, Taiwan, Turkey	1				
First author's affiliation	Emergency Medicine	46				
	Surgery	32				
	Radiology	15				
	Internal medicine	3				
	Gynecology & Obstetrics	2				
	Urology, intensive care	1				
USG performer	Emergency physician	37				
	Surgeon	20				
	Radiology	24				
	Other (nurse, technicians etc.)	7				
	Multiple performer	6				
	N/A	6				

Abbreviation: USG, ultrasonogram.

The authors were from 14 countries, primarily the USA (69) and Italy (8). There was no significant relationship between whether a study was completed in the USA and the total or average number of citations ($P = .156$ and $P = .210$). While there was no significant difference between the number of citations in randomized controlled (RCT) studies and other (NRT) studies (RCT: 136.0 ± 11.9, NRT: 129.7 ± 7.7; $P = .789$),

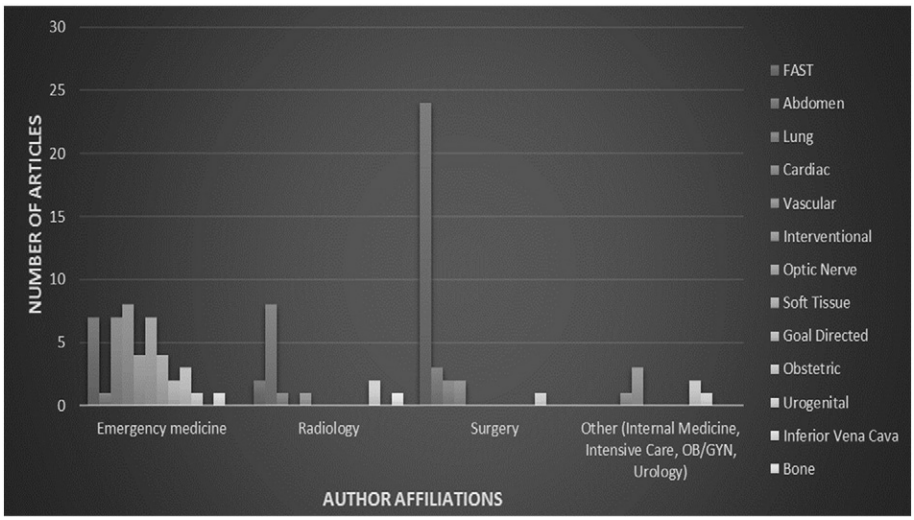

Fig. 1. Ultrasound fields of study based on the primary authors' specialties.

the median annual citation rate was higher among the RCTs (RCT: 12.7 ± 2.4, NRT: 8.4 ± 0.5; $P = .013$).

4. Discussion

The number of times a scientific paper is cited in other publications is an approximate measure of the impact of the work in that field. We evaluated this property for highly-cited studies on ultrasonography in emergency medicine; however, because older articles often have a greater number of total citations, the annual citation rate was also studied.

In 2006 and 2015, the most-cited studies in emergency medicine were evaluated [3,4]. In these studies, the 100 most-cited studies in emergency medicine were evaluated over two time periods. In one study investigating the most-cited publications on imaging in trauma patients, Dolan et al. were excluded studies where the evaluator of the images was not a radiologist [6]. No previous bibliometric study has evaluated emergency medicine subspecialty fields. This is the first bibliometric study conducted in a subspeciality of emergency medicine.

Scopus, Google Scholar, or WOS can be used to determine how often an article has been cited so that bibliographic studies can be performed. Because non-English articles are included in Scopus, it has a wider range of citations than WOS [7]. For this reason, the 100 most-cited articles were determined based on data provided by Scopus. However, in determining the number of citations, including only articles published in medical journals may not be adequate in reflecting current trends. Google Scholar is able to scan additional conference proceedings, and the WOS includes non-conventional citations in online documents, university theses, and web sites. Using Google Scholar, many researchers can expect 15% to 30% increases in their h-indicies over those obtained using Scopus and WOS. Google Scholar is a valid tool for Health Science researchers who calculate bibliometric indicators [8]. In this study, we aimed to determine the most-cited articles in the ultrasonography field of emergency medicine and to identify current areas of interest. These parameters can also be used to determine the most popular articles on any topic. For this reason, we evaluated the total number of citations, as obtained from Google Scholar, separately.

Almost half of the 100 most-cited ultrasonography studies in emergency medicine were conducted by emergency physicians. In 79% of those authored primarily by emergency physicians, the US images were obtained by emergency physicians. The other studies conducted by emergency physicians included a wider range of fields when compared to other specialties. The ultrasonographic imaging technique, which was first widespread among radiologists and specialists, is now performed widely by emergency physicians. Today, an emergency physician is expected to safely and effectively perform ultrasonography for diagnosis and intervention [9]. “Emergency ultrasonography” defines diagnostic ultrasonographic imaging performed and evaluated by the emergency physician in the emergency department on the emergency patient [10]. We evaluated studies on ultrasonography in the emergency department, including those that examined bedside US. In one-fourth of the 100 most-cited articles, US evaluation was performed by radiologists. Many recent US studies were conducted by clinicians, and that most imaging US users are non-radiologists is itself remarkable.

With the development of portable technologies, US has become widespread among clinicians in many fields for spot diagnosis, and the use of this technique is increasing [11]. Ultrasound is becoming a routine part of the clinical examination and has recently been referred to as the “stethoscope of the future” [12]. Point of care ultrasound (POCUS) is defined as bedside ultrasonographical imaging performed and interpreted by the clinician [13]. Of the 12 areas of focus found in highly-cited studies on US, we found that FAST and abdominal US were the most common, and this was not surprising because emergency ultrasonographical imaging was typically used in trauma and investigational studies. However, when ranked by annual citation rate, the areas of focus were different. Most of the highly-cited studies conducted after 2000 concentrated on POCUS. Vascular, thoracic, and optic nerve sheath diameter studies were among those with the greatest average citation rate.

In the emergency department, 36% of the most-cited US studies were conducted to evaluate intra-abdominal and intrathoracic pathologies in trauma patients. Dolan et al. evaluated the 100 most-cited studies on imaging in trauma, and only one article in our set of most-cited studies was also in their set of studies (“Abdominal ultrasound as a reliable indicator for conclusive laparotomy in blunt abdominal trauma” by Bode et al. and published in The Journal of Trauma, Vol. 34, pp. 27–31). In addition, they identified only 2 studies using US [6], whereas US studies on trauma patients were popular. We found that 3 of the 10 most-cited articles described studies evaluating pneumothorax in trauma.

4.1. Limitations

Like all bibliometric studies, this study has many limitations. First, Scopus was used to search for the most-cited articles. The number of citations is known to differ between databases [7]. The studies were evaluated based on the number of citations and mean annual citation rate, but not sorted accordingly. Finally, although the number of citations and mean annual citation rate are traditional parameters for evaluating the scientific value of an article, its contribution to science cannot be evaluated by these measures alone.

5. Conclusion

The most-cited articles on ultrasonography addressed either FAST or abdominal US. Vascular and lung US studies received the most citations per year. Many physicians from a wide range of specialties conducted studies in this area, and approximately half of the primary authors of the most-cited studies were emergency physicians.

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