

# The 100 most-cited articles on chronic venous disease: a bibliometric analysis

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## Abstract

**Objective:** To use bibliometric analysis to understand characteristics and trends in the research on chronic venous disease (CVD), which affects patients' quality of life by causing pain, swelling, and ulceration.

**Methods:** We searched the Thomson Reuters Web of Science citation indexing database to identify the 100 most-cited manuscripts on CVD. The resulting articles were analyzed by title, author, institution, topic, year of publication, and country of origin.

**Results:** The *Journal of Vascular Surgery* published the most manuscripts on CVD ( $n = 36$ ) and was the most-cited journal ( $n = 5356$ ). The United Kingdom was the country with the greatest number of publications ( $n = 32$ ). Imperial College London was the institution with the highest number of publications ( $n = 6$ ). Endovenous thermal ablation was the most widely studied research specialty ( $n = 30$ ).

**Conclusions:** Our analysis showed that the majority of CVD research is carried out in Western countries, and that the number of research studies is increasing in line with recent advances in CVD.

## Keywords

Bibliometric analysis, chronic venous disease, varicose vein, citation, database, manuscript

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## Introduction

Chronic venous disease (CVD) is a common condition in Western countries, typically affecting 164 people for every

1000 individuals.<sup>1</sup> Among the various clinical manifestations of CVD, varicose veins are the most common,<sup>2</sup> and can

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cause symptoms such as pain, swelling, throbbing, cramping, and itching. In more severe cases, CVD can cause superficial thrombophlebitis, bleeding, and lipodermatosclerosis, as well as ulceration, which can affect patients' quality of life.<sup>3</sup> In Asian populations, the prevalence of CVD is reportedly lower than that in non-Hispanic white populations.<sup>4</sup> However, the lower rates of superficial venous surgery among Asians residing in the UK have been reported as resulting from cultural and religious differences rather than from inherent differences.

CVD research is a well-established field of study, which has diversified with the recent introduction of various treatment modalities. Bibliometric analysis allows research trends to be analyzed by evaluating authors, journals, countries, and trends of publication.<sup>6</sup> The aim of the present study was to understand the characteristics and trends in CVD research using bibliometric analysis. Given the large number of publications on CVD in the literature, we performed bibliometric analysis on the 100 most-cited articles, with citation ranking considered to reflect the level of influence.<sup>7</sup>

## Methods

The Institutional Review Board of Hallym Medical University approved the review of medical articles using a publicly available database (approval no. HKS 2019-05-025). A search of the Thomson Reuters Web of Science citation indexing database and research platform was completed on January 17, 2019. The terms used in the search were "varicose vein", "saphenous vein", "chronic venous disease", and "chronic venous insufficiency". Inclusion criteria were CVD limited to lower extremities, superficial CVD, and multiple clinical manifestations of CVD including varicose vein, venous ulcer, and lipodermatosclerosis in the CEAP classification.<sup>8</sup> Synonyms

included varicose, varix, varices, and varicosities. Exclusion criteria included deep vein disease and venous disease in locations other than the lower extremities. The resulting dataset was filtered to include only full-text manuscripts in English. These manuscripts were subsequently sorted by number of citations, a method initially developed by Paladugu and colleagues.<sup>9</sup> Analysis of individual articles was performed by two independent reviewers (HJ and JWH) to verify the relationship to CVD. The 100 most-cited manuscripts were identified, and the resulting dataset was further evaluated for title, first and senior author, institution, topic, year of publication, and country of origin. The individual and 5-year impact factors of the journals in which the papers were published were recorded. To prevent potential bias for older manuscripts having had more time to be cited, the citation rate was determined by dividing the citation number by the number of years since publication.

## Results

The Web of Science database search returned 7639 full-length English language articles. Table 1 lists the 100 most cited of these articles. The number of citations ranged from 403 for Evans et al.<sup>10</sup> ("Prevalence of varicose veins and chronic venous insufficiency in men and women in the general population: Edinburgh vein study") to 86 for Gillet et al.<sup>11</sup> ("Side-effects and complications of foam sclerotherapy of the great and small saphenous veins: a controlled multicenter prospective study including 1025 patients"). The mean number of citations for all articles was  $150.4 \pm 73.1$ . The citation rate was highest for the review article "The care of patients with varicose veins and associated chronic venous diseases: clinical practice guidelines of the society for vascular surgery and the

**Table 1.** The 100 most-cited articles on chronic venous disease.

| Rank | Article   | Citations | Citation rate |
|------|---|-----------|---------------|
| 1    | Evans CJ, Fowkes FGR, Ruckley CV, Lee AJ. Prevalence of varicose veins and chronic venous insufficiency in men and women in the general population: Edinburgh Vein Study. <i>J Epidemiol Community Health</i> 1999; 53(3): 149–153.   | 403       | 20.2          |
| 2    | Callam MJ. Epidemiology of varicose veins. <i>Br J Surg</i> 1994; 81(2): 167–173.   | 402       | 16.1          |
| 3    | Gloviczki P, Comerota AJ, Dalsing MC, et al. The care of patients with varicose veins and associated chronic venous diseases: clinical practice guidelines of the Society for Vascular Surgery and the American Venous Forum. <i>J Vasc Surg</i> 2011; 53: 2S–48S.                | 387       | 48.4          |
| 4    | Min RJ, Khilani N, Zimmet SE. Endovenous laser treatment of saphenous vein reflux: long-term results. <i>J Vasc Interv Radiol</i> 2003; 14(8): 991–996.   | 378       | 23.6          |
| 5    | Beebe-Dimmer JL, Pfeifer JR, Engle JS, Schottenfeld D. The epidemiology of chronic venous insufficiency and varicose veins. <i>Ann Epidemiol</i> 2005; 15(3): 175–184.  | 330       | 23.6          |
| 6    | Nicolaides AN. Investigation of chronic venous insufficiency – a consensus statement. <i>Circulation</i> 2000; 102(20): E126–E63.   | 282       | 14.8          |
| 7    | Brand FN, Dannenberg AL, Abbott RD, Kannel WB. The epidemiology of varicose veins – The Framingham study. <i>Am J Prev Med</i> 1988; 4(2): 96–101.  | 270       | 8.7           |
| 8    | Tessari L, Cavezzi A, Frullini A. Preliminary experience with a new sclerosing foam in the treatment of varicose veins. <i>Dermatol Surg</i> 2001; 27(1): 58–60.  | 266       | 14.8          |
| 9    | Rasmussen LH, Lawaetz M, Bjoern L, Vennits B, Blemings A, Eklof B. Randomized clinical trial comparing endovenous laser ablation, radiofrequency ablation, foam sclerotherapy and surgical stripping for great saphenous varicose veins. <i>Br J Surg</i> 2011; 98(8): 1079–1087. | 257       | 32.1          |
| 10   | Dwerryhouse S, Davies B, Harradine K, Earnshaw JJ. Stripping the long saphenous vein reduces the rate of reoperation for recurrent varicose veins: five-year results of a randomized trial. <i>J Vasc Surg</i> 1999; 29(4): 589–592.  | 256       | 12.8          |
| 11   | Navarro L, Min RJ, Bone C. Endovenous laser: A new minimally invasive method of treatment for varicose veins – preliminary observations using an 810 nm diode laser. <i>Dermatol Surg</i> 2001; 27(2): 117–122.   | 255       | 14.2          |
| 12   | Jones L, Braithwaite BD, Selwyn D, Cooke S, Earnshaw JJ. Neovascularisation is the principal cause of varicose vein recurrence: results of a randomised trial of stripping the long saphenous vein. <i>Eur J Vasc Endovasc Surg</i> 1996; 12(4): 442–445.                         | 254       | 11            |
| 13   | Valencia IC, Falabella H, Kirsner RS, Eaglstein WH. Chronic venous insufficiency and venous leg ulceration. <i>J Am Acad Dermatol</i> 2001; 44(3): 401–421.   | 251       | 13.9          |

(continued)

Table 1. Continued.

| Rank | Article  | Citations | Citation rate |
|------|--|-----------|---------------|
| 14   | Proebstle TM, Lehr HA, Kargl A, et al. Endovenous treatment of the greater saphenous vein with a 940-nm diode laser: thrombotic occlusion after endoluminal thermal damage by laser-generated steam bubbles. <i>J Vasc Surg</i> 2002; 35(4): 729-736.                              | 245       | 14.4          |
| 15   | Ruckley CV. Socioeconomic impact of chronic venous insufficiency and leg ulcers. <i>Angiology</i> 1997; 48(1): 67-69.  | 230       | 10.5          |
| 16   | Min RJ, Zimmet SE, Isaacs MN, Forrestal MD. Endovenous laser treatment of the incompetent greater saphenous vein. <i>J Vasc Interv Radiol</i> 2001; 12(10): 1167-1171.   | 226       | 12.6          |
| 17   | Meissner MH, Manzo RA, Bergelin RO, Markel A, Strandness DE, Jr. Deep venous insufficiency: the relationship between lysis and subsequent reflux. <i>J Vasc Surg</i> 1993; 18(4): 596-605; discussion 6-8.   | 212       | 8.2           |
| 18   | Eberhardt RT, Raffetto JD. Chronic venous insufficiency. <i>Circulation</i> 2005; 111(18): 2398-2409.  | 209       | 14.9          |
| 19   | Rautio T, Ohinmaa A, Perala J, et al. Endovenous obliteration versus conventional stripping operation in the treatment of primary varicose veins: a randomized controlled trial with comparison of the costs. <i>J Vasc Surg</i> 2002; 35(5): 958-965.                             | 197       | 11.6          |
| 20   | Merchant RF, Pichot O. Long-term outcomes of endovenous radiofrequency obliteration of saphenous reflux as a treatment for superficial venous insufficiency. <i>J Vasc Surg</i> 2005; 42(3): 502-509; discussion 9.  | 186       | 13.3          |
| 21   | Bradbury A, Evans C, Allan P, Lee A, Ruckley CV, Fowkes FGR. What are the symptoms of varicose veins? Edinburgh vein study cross sectional population survey. <i>BMJ</i> 1999; 318(7180): 353-356.   | 184       | 9.2           |
| 22   | Darwood RJ, Theivacumar N, Dellagrammaticas D, Mavor AID, Gough MJ. Randomized clinical trial comparing endovenous laser ablation with surgery for the treatment of primary great saphenous varicose veins. <i>Br J Surg</i> 2008; 95(3): 294-301.                                 | 178       | 16.2          |
| 23   | Hamel-Desnos C, Desnos P, Wollmann JC, Ouvry P, Mako S, Allaert FA. Evaluation of the efficacy of polidocanol in the form of foam compared with liquid form in sclerotherapy of the greater saphenous vein: initial results. <i>Dermatol Surg</i> 2003; 29(12): 1170-1175.         | 178       | 11.1          |
| 24   | Jia X, Mowatt G, Burr JM, Cassar K, Cook J, Fraser C. Systematic review of foam sclerotherapy for varicose veins. <i>Br J Surg</i> 2007; 94(8): 925-936.   | 177       | 14.8          |
| 25   | Gloviczki P, Bergan JJ, Rhodes JM, et al. Mid-term results of endoscopic perforator vein interruption for chronic venous insufficiency: lessons learned from the North American Subfascial Endoscopic Perforator Surgery registry. <i>J Vasc Surg</i> 1999; 29(3): 489-499.        | 170       | 8.5           |
| 26   | Rasmussen LH, Bjoern L, Lawaetz M, Blemings A, Lawaetz B, Eklof B. Randomized trial comparing endovenous laser ablation of the great saphenous vein with high ligation and stripping in patients with varicose veins: short-term results. <i>J Vasc Surg</i> 2007; 46(2): 308-315. | 167       | 13.9          |

(continued)

Table 1. Continued.

| Rank | Article   | Citations | Citation rate |
|------|---|-----------|---------------|
| 27   | Labropoulos N, Leon M, Nicolaides AN, Giannoukas AD, Volteas N, Chan P. Superficial venous insufficiency: correlation of anatomic extent of reflux with clinical symptoms and signs. <i>J Vasc Surg</i> 1994; 20(6): 953-958.                         | 165       | 6.6           |
| 28   | Fischer R, Linde N, Duff C, Jeanneret C, Chandler JG, Seeber P. Late recurrent saphenofemoral junction reflux after ligation and stripping of the greater saphenous vein. <i>J Vasc Surg</i> 2001; 34(2): 236-240.                                    | 164       | 9.1           |
| 29   | Smith JJ, Garratt AM, Guest M, Greenhalgh RM, Davies AH. Evaluating and improving health-related quality of life in patients with varicose veins. <i>J Vasc Surg</i> 1999; 30(4): 710-719.  | 163       | 8.2           |
| 30   | Puggioni A, Kalra M, Mozes G, Gloviczki P. Endovenous laser therapy and radiofrequency ablation of the great saphenous vein: analysis of early efficacy and complications. <i>J Vasc Surg</i> 2005; 42(3): 488-493.                                   | 163       | 11.6          |
| 31   | Scott TE, Lamorte WW, Gorin DR, Menzoian JO. Risk factors for chronic venous insufficiency - a dual case-control study. <i>J Vasc Surg</i> 1995; 22(5): 622-628.  | 162       | 6.8           |
| 32   | Raju S, Fredericks R. Valve reconstruction procedures for nonobstructive venous insufficiency: rationale, techniques, and results in 107 procedures with two- to eight-year follow-up. <i>J Vasc Surg</i> 1988; 7(2): 301-310.                        | 153       | 4.9           |
| 33   | Rose SS, Ahmed A. Some thoughts on the etiology of varicose veins. <i>J Cardiovasc Surg</i> 1986; 27(5): 534-543.   | 151       | 4.6           |
| 34   | Labropoulos N, Delis K, Nicolaides AN, Leon M, Ramaswami G, Volteas N. The role of the distribution and anatomic extent of reflux in the development of signs and symptoms in chronic venous insufficiency. <i>J Vasc Surg</i> 1996; 23(3): 504-510.  | 148       | 6.4           |
| 35   | Forlee MV, Grouden M, Moore DJ, Shanik G. Stroke after varicose vein foam injection sclerotherapy. <i>J Vasc Surg</i> 2006; 43(1): 162-164.   | 144       | 11.1          |
| 36   | Fruzzini A, Cavezzi A. Sclerosing foam in the treatment of varicose veins and telangiectases: history and analysis of safety and complications. <i>Dermatol Surg</i> 2002; 28(1): 11-5.   | 144       | 8.5           |
| 37   | van Rij AM, Jiang P, Solomon C, Christie RA, Hill GB. Recurrence after varicose vein surgery: a prospective long-term clinical study with duplex ultrasound scanning and air plethysmography. <i>J Vasc Surg</i> 2003; 38(5): 935-943.                | 138       | 8.6           |
| 38   | Weiss RA, Weiss MA. Controlled radiofrequency endovenous occlusion using a unique radiofrequency catheter under duplex guidance to eliminate saphenous varicose vein reflux: a 2-year follow-up. <i>Dermatol Surg</i> 2002; 28(1): 38-42.             | 135       | 7.9           |
| 39   | Proebstle TM, Vago B, Alm J, Gockertitz O, Lebard C, Pichot O. Treatment of the incompetent great saphenous vein by endovenous radiofrequency powered segmental thermal ablation: first clinical experience. <i>J Vasc Surg</i> 2008; 47(1): 151-156. | 133       | 12.1          |
| 40   | Mundy L, Merlin TL, Ffritridge RA, Hiller JE. Systematic review of endovenous laser treatment for varicose veins. <i>Br J Surg</i> 2005; 92(10): 1189-1194.   | 133       | 9.5           |

(continued)

Table 1. Continued.

| Rank | Article  | Citations | Citation rate |
|------|--|-----------|---------------|
| 41   | Proebstle TM, Krummenauer F, Gul D, Knop J. Nonocclusion and early reopening of the great saphenous vein after endovenous laser treatment is fluence dependent. <i>Dermatol Surg</i> 2004; 30(2 Pt 1): 174-178.                      | 131       | 8.7           |
| 42   | Diehm C, Trampisch HJ, Lange S, Schmidt C. Comparison of leg compression stocking and oral horse-chestnut seed extract therapy in patients with chronic venous insufficiency. <i>Lancet</i> 1996; 347(8997): 292-294.                | 130       | 5.7           |
| 43   | Mozes G, Kalra M, Carmo M, Swenson L, Gloviczki P. Extension of saphenous thrombus into the femoral vein: a potential complication of new endovenous ablation techniques. <i>J Vasc Surg</i> 2005; 41(1): 130-135.                   | 127       | 9.1           |
| 44   | Sarin S, Scurr JH, Smith PDC. Assessment of stripping the long saphenous vein in the treatment of primary varicose veins. <i>Br J Surg</i> 1992; 79(9): 889-893.   | 126       | 4.7           |
| 45   | Winterborn RJ, Foy C, Earnshaw JJ. Causes of varicose vein recurrence: late results of a randomized controlled trial of stripping the long saphenous vein. <i>J Vasc Surg</i> 2004; 40(4): 634-639.                                  | 125       | 8.3           |
| 46   | Ruckley CV, Evans CJ, Allan PL, Lee AJ, Fowkes FGR. Chronic venous insufficiency: clinical and duplex correlations. The Edinburgh Vein Study of venous disorders in the general population. <i>J Vasc Surg</i> 2002; 36(3): 520-525. | 124       | 7.3           |
| 47   | Raju S. Venous insufficiency of the lower limb and stasis ulceration. Changing concepts and management. <i>Ann Surg</i> 1983; 197(6): 688-697.   | 123       | 3.4           |
| 48   | van Rij AM, Jones GT, Hill GB, Jiang P. Neovascularization and recurrent varicose veins: more histologic and ultrasound evidence. <i>J Vasc Surg</i> 2004; 40(2): 296-302.   | 122       | 8.1           |
| 49   | Fowkes FGR, Evans CJ, Lee AJ. Prevalence and risk factors of chronic venous insufficiency. <i>Angiology</i> 2001; 52: S5-S15.  | 121       | 6.7           |
| 50   | Manfrini S, Gasbarro V, Danielsson G, et al. Endovenous management of saphenous vein reflux. Endovenous Reflux Management Study Group. <i>J Vasc Surg</i> 2000; 32(2): 330-342.  | 121       | 6.4           |
| 51   | Hingorani AP, Ascher E, Markevich N, et al. Deep venous thrombosis after radiofrequency ablation of greater saphenous vein: a word of caution. <i>J Vasc Surg</i> 2004; 40(3): 500-504.  | 121       | 8.1           |
| 52   | Nyamekye I, Shephard NA, Davies B, Heather BP, Earnshaw JJ. Clinicopathological evidence that neovascularisation is a cause of recurrent varicose veins. <i>Eur J Vasc Endovasc Surg</i> 1998; 15(5): 412-415.                       | 121       | 5.8           |
| 53   | Padberg FT, Johnston MV, Sisto SA. Structured exercise improves calf muscle pump function in chronic venous insufficiency: a randomized trial. <i>J Vasc Surg</i> 2004; 39(1): 79-87.  | 117       | 7.8           |
| 54   | Lim CS, Davies AH. Pathogenesis of primary varicose veins. <i>Br J Surg</i> 2009; 96(11): 1231-1242.   | 117       | 11.7          |
| 55   | Timperman PE, Sichlau M, Ryu RK. Greater energy delivery improves treatment success of endovenous laser treatment of incompetent saphenous veins. <i>J Vasc Interv Radiol</i> 2004; 15(10): 1061-1063.                               | 117       | 7.8           |

(continued)

Table 1. Continued.

| Rank | Article  | Citations | Citation rate |
|------|--|-----------|---------------|
| 56   | Raffetto JD, Khalil RA. Mechanisms of varicose vein formation: valve dysfunction and wall dilation. <i>Phlebology</i> 2008; 23(2): 85–98.  | 116       | 10.5          |
| 57   | Erickson CA, Lanza DJ, Karp DL, et al. Healing of venous ulcers in an ambulatory care program – the roles of chronic venous insufficiency and patient compliance. <i>J Vasc Surg</i> 1995; 22(5): 629–636.   | 116       | 4.8           |
| 58   | Maffei FHA, Magaldi C, Pinho SZ, et al. Varicose veins and chronic venous insufficiency in Brazil – prevalence among 1755 inhabitants of a country town. <i>Int J Epidemiol</i> 1986; 15(2): 210–217.  | 114       | 3.5           |
| 59   | Cavezzi A, Frullini A, Ricci S, Tessari L. Treatment of varicose veins by foam sclerotherapy: two clinical series. <i>Phlebology</i> 2002; 17(1): 13–18.   | 113       | 6.6           |
| 60   | Yamaki T, Nozaki M, Iwasaka S. Comparative study of duplex-guided foam sclerotherapy and duplex-guided liquid sclerotherapy for the treatment of superficial venous insufficiency. <i>Dermatol Surg</i> 2004; 30(5): 718–722; discussion 22.                                     | 113       | 7.5           |
| 61   | Proebstle TM, Moehler T, Gul D, Herdemann S. Endovenous treatment of the great saphenous vein using a 1,320 nm Nd:YAG laser causes fewer side effects than using a 940 nm diode laser. <i>Dermatol Surg</i> 2005; 31(12): 1678–1683; discussion 83–84.                           | 111       | 7.9           |
| 62   | Pichot O, Kabnick LS, Creton D, Merchant RF, Schuller-Petroviae S, Chandler JG. Duplex ultrasound scan findings two years after great saphenous vein radiofrequency endovenous obliteration. <i>J Vasc Surg</i> 2004; 39(1): 189–195.  | 111       | 7.4           |
| 63   | Jantet G, Grp RS. Chronic venous insufficiency: Worldwide results of the RELIEF study. <i>Angiology</i> 2002; 53(3): 245–256.  | 111       | 6.5           |
| 64   | Neglen P, Raju S. A comparison between descending phlebography and duplex doppler investigation in the evaluation of reflux in chronic venous insufficiency – a challenge to phlebography as the gold standard. <i>J Vasc Surg</i> 1992; 16(5): 687–693.                         | 111       | 4.1           |
| 65   | Darke SG. The morphology of recurrent varicose veins. <i>Eur J Vasc Surg</i> 1992; 6(5): 512–517.  | 110       | 4.1           |
| 66   | Proebstle TM, Gul D, Lehr HA, Kargl A, Knop J. Infrequent early recanalization of greater saphenous vein after endovenous laser treatment. <i>J Vasc Surg</i> 2003; 38(3): 511–516.  | 109       | 6.8           |
| 67   | Wright D, Gobin JP, Bradbury AW, et al. Varisolve (R) polydocanol microfoam compared with surgery or sclerotherapy in the management of varicose veins in the presence of trunk vein incompetence: European randomized controlled trial. <i>Phlebology</i> 2006; 21(4): 180–190. | 108       | 8.3           |
| 68   | Cabrera J, Cabrera J, Garcia-Olmedo MA. Treatment of varicose long saphenous veins with sclerosant in microfoam form: long-term outcomes. <i>Phlebology</i> 2000; 15(1): 19–23.  | 108       | 5.7           |

(continued)

Table 1. Continued.

| Rank | Article   | Citations | Citation rate |
|------|---|-----------|---------------|
| 69   | Kabnick LS. Outcome of different endovenous laser wavelengths for great saphenous vein ablation. <i>J Vasc Surg</i> 2006; 43(1): 88–93.   | 108       | 8.3           |
| 70   | Myers KA, Jolley D, Clough A, Kirwan J. Outcome of ultrasound-guided sclerotherapy for varicose veins: medium-term results assessed by ultrasound surveillance. <i>Eur J Vasc Endovasc Surg</i> 2007; 33(1): 116–121.   | 106       | 8.8           |
| 71   | Gandhi RH, Irizarry E, Nackman GB, Halpern VJ, Tilson MD. Analysis of the connective-tissue matrix and proteolytic activity of primary varicose veins. <i>J Vasc Surg</i> 1993; 18(5): 814–820.   | 106       | 4.1           |
| 72   | Sarin S, Scurr JH, Smith PDC. Stripping of the long saphenous vein in the treatment of primary varicose veins. <i>Br J Surg</i> 1994; 81(10): 1455–1458.  | 105       | 4.2           |
| 73   | Badier-Commander C, Verbeuren T, Lebard C, Michel JB, Jacob MP. Increased TIMP/MMP ratio in varicose veins: a possible explanation for extracellular matrix accumulation. <i>J Pathol</i> 2000; 192(1): 105–112.  | 105       | 5.5           |
| 74   | Proebstle TM, Moehler T, Herdemann S. Reduced recanalization rates of the great saphenous vein after endovenous laser treatment with increased energy dosing: definition of a threshold for the endovenous fluence equivalent. <i>J Vasc Surg</i> 2006; 44(4): 834–839. | 104       | 8             |
| 75   | Goldman MP, Mauricio M, Rao J. Intravascular 1320-nm laser closure of the great saphenous vein: a 6- to 12-month follow-up study. <i>Dermatol Surg</i> 2004; 30(11): 1380–1385.   | 104       | 6.9           |
| 76   | Marston WA, Carlin RE, Passman MA, Farber MA, Keagy BA. Healing rates and cost efficacy of outpatient compression treatment for leg ulcers associated with venous insufficiency. <i>J Vasc Surg</i> 1999; 30(3): 491–498.   | 104       | 5.2           |
| 77   | Rutgers PH, Kistlaar PJ. Randomized trial of stripping versus high ligation combined with sclerotherapy in the treatment of the incompetent greater saphenous vein. <i>Am J Surg</i> 1994; 168(4): 311–315.   | 103       | 4.1           |
| 78   | Travers JP, Brookes CE, Evans J, et al. Assessment of wall structure and composition of varicose veins with reference to collagen, elastin and smooth muscle content. <i>Eur J Vasc Endovasc Surg</i> 1996; 11(2): 230–237.   | 103       | 4.5           |
| 79   | Critchley G, Handa A, Maw A, Harvey A, Harvey MR, Corbett CRR. Complications of varicose vein surgery. <i>Ann R Coll Surg Engl</i> 1997; 79(2): 105–110.  | 102       | 4.6           |
| 80   | Rabe E, Otto J, Schliephake D, Pannier F. Efficacy and safety of great saphenous vein sclerotherapy using standardised polydocanol foam (ESAF): a randomised controlled multicentre clinical trial. <i>Eur J Vasc Endovasc Surg</i> 2008; 35(2): 238–245.               | 101       | 9.2           |
| 81   | Stonebridge PA, Chalmers N, Beggs I, Bradbury AW, Ruckley CV. Recurrent varicose veins – a varicographic analysis leading to a new practical classification. <i>Br J Surg</i> 1995; 82(1): 60–62.   | 100       | 4.2           |
| 82   | Proebstle TM, Gul D, Kargl A, Knop J. Endovenous laser treatment of the lesser saphenous vein with a 940-nm diode laser: early results. <i>Dermatol Surg</i> 2003; 29(4): 357–361.  | 99        | 6.2           |

(continued)



Table 1. Continued.

| Rank | Article   | Citations | Citation rate |
|------|---|-----------|---------------|
| 83   | Raju S, Owen S, Neglen P. The clinical impact of iliac venous stents in the management of chronic venous insufficiency. <i>J Vasc Surg</i> 2002; 35(1): 8–14.   | 98        | 5.8           |
| 84   | Lees TA, Lambert D. Patterns of venous reflux in limbs with skin changes associated with chronic venous insufficiency. <i>Br J Surg</i> 1993; 80(6): 725–728.   | 96        | 3.7           |
| 85   | Jawien A, Grzela T, Ochwat A. Prevalence of chronic venous insufficiency in men and women in Poland: multi-centre cross-sectional study in 40,095 patients. <i>Phlebology</i> 2003; 18(3): 110–122.   | 95        | 5.9           |
| 86   | Lee AJ, Evans CJ, Allan PL, Ruckley CV, Fowkes FGR. Lifestyle factors and the risk of varicose veins: Edinburgh Vein Study. <i>J Clin Epidemiol</i> 2003; 56(2): 171–179.   | 95        | 5.9           |
| 87   | Shepherd AC, Gohel MS, Brown LC, Metcalfe MJ, Hamish M, Davies AH. Randomized clinical trial of VNUS (R) ClosureFAST (TM) radiofrequency ablation versus laser for varicose veins. <i>Br J Surg</i> 2010; 97(6): 810–818.   | 94        | 10.4          |
| 88   | Siribumrungwong B, Noorit P, Wilasrusmee C, Attia J, Thakkinstian A. A Systematic review and meta-analysis of randomised controlled trials comparing endovenous ablation and surgical intervention in patients with varicose vein. <i>Eur J Vasc Endovasc Surg</i> 2012; 44(2): 214–223.                      | 94        | 13.4          |
| 89   | Royle JP. Recurrent varicose veins. <i>World J Surg</i> 1986; 10(6): 944–953.   | 93        | 2.8           |
| 90   | Bountourglou DG, Azzam M, Kakkos SK, Pathmarajah M, Young P, Geroulakos G. Ultrasound-guided foam sclerotherapy combined with sapheno-femoral ligation compared to surgical treatment of varicose veins: early results of a randomised controlled trial. <i>Eur J Vasc Endovasc Surg</i> 2006; 31(1): 93–100. | 92        | 7.1           |
| 91   | Van den Oever R, Hepp B, Debbaut B, Simon I. Socio-economic impact of chronic venous insufficiency. An underestimated public health problem. <i>Int Angiol</i> 1998; 17(3): 161–167.  | 92        | 4.4           |
| 92   | MacKenzie RK, Paisley A, Allan PL, Lee AJ, Ruckley CV, Bradbury AV. The effect of long saphenous vein stripping on quality of life. <i>J Vasc Surg</i> 2002; 35(6): 1197–1203.  | 91        | 5.4           |
| 93   | Eberhardt RT, Raffetto JD. Chronic venous insufficiency. <i>Circulation</i> 2014; 130(4): 333–346.  | 91        | 18.2          |
| 94   | Negus D. Recurrent varicose veins – a national problem. <i>Br J Surg</i> 1993; 80(7): 823–824.  | 90        | 3.5           |
| 95   | van Rij AM, Chai J, Hill GB, Christie RA. Incidence of deep vein thrombosis after varicose vein surgery. <i>Br J Surg</i> 2004; 91(12): 1582–1585.  | 90        | 6             |
| 96   | Ihme N, Kiewewetter H, Jung F, et al. Leg oedema protection from a buckwheat herb tea in patients with chronic venous insufficiency: a single centre, randomised, double blind, placebo controlled clinical trial. <i>Eur J Clin Pharmacol</i> 1996; 50(6): 443–447.  | 89        | 3.9           |
| 97   | Padberg FT, Jr., Pappas PJ, Araki CT, Back TL, Hobson RW, 2nd. Hemodynamic and clinical improvement after superficial vein ablation in primary combined venous insufficiency with ulceration. <i>J Vasc Surg</i> 1996; 24(5): 711–718.  | 88        | 3.8           |

(continued)

Table 1. Continued.

| Rank | Article  | Citations | Citation rate |
|------|--|-----------|---------------|
| 98   | Doganci S, Demirkilic U. Comparison of 980 nm laser and bare-tip fibre with 1470 nm laser and radial fibre in the treatment of great saphenous vein varicosities: a prospective randomised clinical trial. <i>Eur J Vasc Endovasc Surg</i> 2010; 40(2): 254–259. | 88        | 9.8           |
| 99   | Hinchliffe RJ, Ubhi J, Beech A, Ellison J, Braithwaite BD. A prospective randomised controlled trial of VNUS closure versus surgery for the treatment of recurrent long saphenous varicose veins. <i>Eur J Vasc Endovasc Surg</i> 2006; 31(2): 212–218.          | 87        | 6.7           |
| 100  | Gillet JL, Guedes JM, Guex JJ, et al. Side-effects and complications of foam sclerotherapy of the great and small saphenous veins: a controlled multicentre prospective study including 1,025 patients. <i>Phlebology</i> 2009; 24(3): 131–138.                  | 86        | 8.6           |

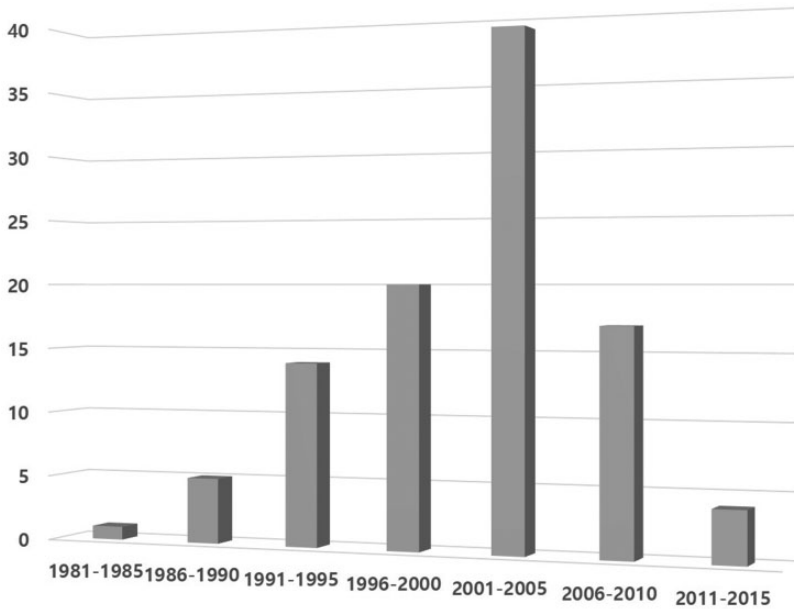
American venous forum” by Głowiczki et al.<sup>12</sup>

The 100 selected articles were published between 1983 and 2014, with half of the articles published after 2000 (n = 60) (Figure 1). The oldest article was published in 1983 by Raju et al.<sup>13</sup> (“Venous insufficiency of the lower-limb and stasis ulceration – changing concepts and management”). The most recent article, published in 2014 by Eberhardt et al.,<sup>14</sup> was a review article on chronic venous insufficiency.

The 100 articles were published across 25 journals in total, with the number of manuscripts published per journal ranging from 1 to 36 (Table 2). The *Journal of Vascular Surgery* published the most articles (n = 36) and had the most citations (n = 5356). *Circulation* had the highest impact factor (18.881) and 5-year impact factor (17.902), and had published three of the most influential articles (582 citations).

The country with the greatest number of publications among the top 100 articles was the United Kingdom, with 32 articles, closely followed by the United States with 30 publications. Among the 100 articles, 98 research studies has been performed in Western countries and the remaining 2 research studies had been performed in Japan and Turkey (Figure 2). Imperial College London was the institution with the highest number of publications among the top 100 articles, with 6 publications, followed by the University of Edinburgh with 5 publications (Table 3). Thirteen authors contributed to four or more papers, among which Thomas Michael Proebstle contributed to seven publications as a senior author (Table 4).

The number of articles in each main research area is shown in Figure 3. Endovenous thermal ablation (ETA) was the most widely studied specialty, with 30 articles among the top 100, followed by nonthermal ablation (NTA) and symptoms, with 14 articles each. Twelve articles studied



**Figure 1.** Number of publications in each 5-year period.

**Table 2.** Journals of the 100 most-cited chronic venous disease articles.

| Journal title   | Impact factor | 5-year impact factor | Number of manuscripts | Number of citations |
|---|---------------|----------------------|-----------------------|---------------------|
| Journal of Vascular Surgery                           | 3.294         | 3.477                | 36                    | 5,356               |
| British Journal of Surgery                            | 5.433         | 6.051                | 13                    | 1,965               |
| Dermatologic Surgery                                  | 2.471         | 2.587                | 10                    | 1,536               |
| European Journal of Vascular and Endovascular Surgery | 3.877         | 3.498                | 9                     | 1,046               |
| Phlebology  | 1.513         | 1.413                | 6                     | 626                 |
| Journal of Vascular and Interventional Radiology      | 2.758         | 3.078                | 3                     | 721                 |
| Circulation   | 18.881        | 17.902               | 3                     | 582                 |
| Angiology   | 3.022         | 2.250                | 3                     | 462                 |

surgical therapy, whereas 11 were related to epidemiology. Nine articles examined disease recurrence after treatment, five articles were on pathogenesis, and five on other topics.

Regarding the number of publications in each 5-year period as shown in Figure 1,

2001 to 2005 had the highest number of publications, with 39 articles (39%). Twenty articles out of 39 (51.2%) were on techniques such as ETA and NTA. During this period, research on treatment modalities was actively introduced. As shown in Figure 3, ETA and NTA were the most



**Figure 2.** Distribution of the 100 most-cited articles by the country of origin of the contributors.

**Table 3.** Institutions with the most articles in the 100 most-cited articles.

| Institution                    | Number of publications | Total number of citations |
|--------------------------------|------------------------|---------------------------|
| Imperial College London        | 6                      | 779                       |
| University of Edinburgh        | 5                      | 927                       |
| Mayo Clinic                    | 4                      | 847                       |
| Gloucestershire Royal Hospital | 4                      | 756                       |
| University of Mainz            | 4                      | 584                       |
| University of Mississippi      | 4                      | 485                       |
| University of Otago            | 3                      | 350                       |
| University of Heidelberg       | 3                      | 345                       |

widely studied topics. In the 10 years from 2006 to 2015, 17 out of 21 articles (80.9%) were on ETA and NTA.

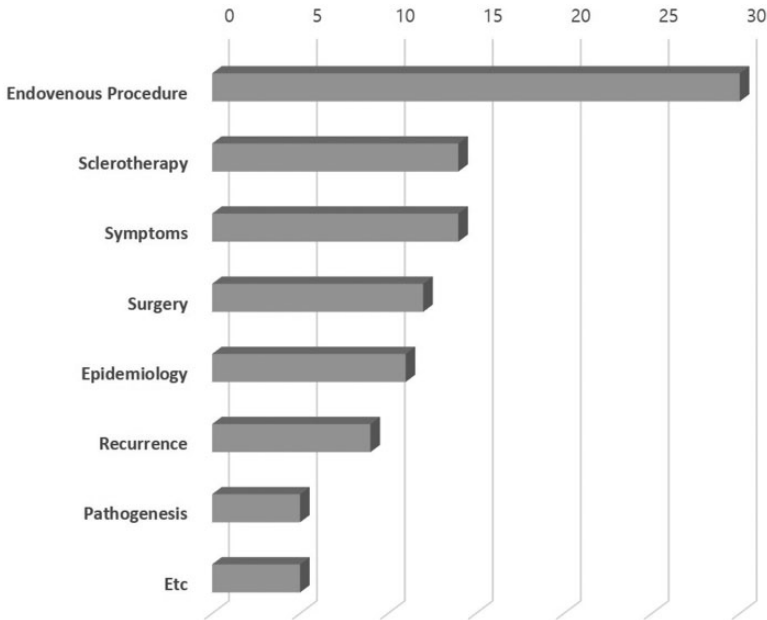
## Discussion

Regarding the history of surgical treatment for CVD, Trendelenburg introduced saphenous vein ligation in 1890 while Homan introduced ligation of the saphenofemoral

**Table 4.** Authors that contributed four or more articles in the 100 most-cited articles.

| Author        | No. of articles | Position on author list                             |
|---------------|-----------------|---|
| Proebstle TM  | 7               | Senior author (7)                                   |
| Ruckley CV    | 7               | First (2), third (1), fourth (1), fifth (3)         |
| Lee AJ        | 6               | First (1), third (1), fourth (3), senior author (1) |
| Fowkes FGR    | 5               | First (1), second (1), fifth (1), senior author (2) |
| Evans CJ      | 5               | First (1), second (3), senior author (1)            |
| Earnshaw JJ   | 4               | Senior author (4)                                   |
| Raju S        | 4               | First (3), senior author (1)                        |
| Gloviczki P   | 4               | First (2), fifth (2)                                |
| Raffetto JD   | 4               | First (1), second (2), fourteenth (1)               |
| Nicolaides AN | 4               | First (1), third (2), eighth (1)                    |
| Gul D         | 4               | Second (2), third (2)                               |
| Allan PI      | 4               | Third (4)   |
| Knop J        | 4               | Fourth (2), fifth (1), seventh (1)                  |

junction in 1916. In the 1890s, excision of the great saphenous vein was introduced by Charles Mayo, and can be considered as the beginning of stripping. In the 1990s, ETA techniques including laser ablation and radiofrequency were introduced and adapted as an alternative treatment to traditional stripping.<sup>15</sup> More recently, ETA techniques have undergone rapid development, and in 2013, the National Institute for Health and Care Excellence recommended endovenous thermal ablation as the preferred treatment for symptomatic varicose veins.<sup>16</sup> NTA, including ultrasound guided foam sclerotherapy with a lower risk of nerve injury, has recently been adopted and is widely used at present while research is ongoing. Furthermore,



**Figure 3.** Number of publications among the 100 most-cited articles by topic (ETA: endovenous thermal ablation, NTA: nonthermal ablation).

NTA alternatives such as mechanochemical endovenous ablation and endovenous delivery of cyanoacrylate tissue adhesive are also being studied.<sup>17</sup>

Bibliometric analysis is a research method that allows the analysis of publication quality as well as the scientific productivity in a field of research.<sup>18</sup> The citation of articles, in particular, is a robust method for analyzing the quality and impact of publications.<sup>19</sup> For these reasons, the 100 most-cited articles were analyzed to evaluate the characteristics and trends in CVD research in the present study. In Table 2, the top four cited journals on CVD were related to surgery. To date, surgical journals have played an important role in CVD research. Although new treatment modalities for CVD have recently been adopted, the cited manuscripts discuss the ongoing role of surgeons with a general understanding of the disease and ability to provide appropriate treatment.

Our study found that CVD research initially focused on the characteristics of the disease, including epidemiology, symptoms, recurrence, and pathogenesis. With recent developments in technology, treatment for CVD is becoming less invasive and less complex. Alongside this trend, CVD research is becoming more focused on new treatment modalities. Thus, comparative studies and meta-analyses on newly developed modalities are likely to continue to increase.

Limitations of this research include potential biases related to the bibliometric analysis, including language bias, institutional bias, and influential researcher bias. Older articles have a greater potential for citation because of their relatively longer period of time in the publication domain. To control for this, the number of citations was divided by the number of years after publication to yield a citation rate, which is provided alongside the citation number

in Table 1. Despite these mitigations, more recent relevant articles may have been underrepresented in this study.

## Conclusion

Our bibliometric analysis of CVD research examined the characteristics and trends of publications. Research on CVD is typically carried out in Western countries and is continuing to increase with the introduction of new treatment modalities.


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The authors declare that there is no conflict of interest.

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