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Original Research

Changes in rates of vascular procedure types and lower extremity amputations in Finland for 2007–2017 inclusive, a population cohort study of 69,523 revascularizations

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ABSTRACT

Introduction: Since 2000 the numbers of both open and endovascular revascularization procedures have increased. Despite these increases, the number of major lower extremity amputations (LEAs) has remained relatively constant. The aim of the present study was to assess the number of vascular procedures in relation to the frequency of major LEAs in Finland.

Methods: The Finnish National Institute for Health and Welfare (THL) administers a national registry of all procedures conducted by official healthcare providers in Finland. Data regarding all revascularization procedures and major LEAs between 2007 and 2017 inclusive, were collected from the THL registry. The rates of both open and endovascular procedures were analyzed.

Results: A total of 69,523 revascularization procedures were registered over the 11-year period. Of all revascularizations, 22.6% were endovascular in 2007, which rose to 60.5% in 2017. The annual rates of vascular procedures per 100,000 inhabitants increased from 66 in 2007 to 172 in 2017 (increase 10 procedures per year, 95% CI 8.6–12.3, $P < 0.01$) There was a significant increase (by 141 per year, 95% CI 110–174, $P < 0.01$) for open revascularizations (2705 operations in 2007, 3992 operations in 2017) and (by 491 per year, 95% CI 433–550, $P < 0.01$) for endovascular revascularizations (791 in 2007–5514 in 2017). Open aorto-iliac segment revascularization decreased, whereas the numbers of procedures increased for all other arterial segments.

The overall frequency of amputations was 18–20 per 100,000. The frequency of amputations in the subpopulation over 65 years old decreased from 93 in 2007 to 72 in 2017 ($P < 0.01$).

Conclusion: The present study demonstrated increases in vascular surgery procedures over the 11-year study-period. The increase was greatest for endovascular procedures. During the same period, there was a significant decrease in the frequency of major LEAs in the > 65-year-old subpopulation.

1. Introduction

Symptomatic peripheral arterial disease (PAD) is a cause of significant morbidity and mortality [1–4].The most severe manifestation of PAD is critical limb ischemia (CLI). Without revascularization, 30% of patients will undergo major lower extremity amputation (LEA) and 25% of them will die within one year of presentation with CLI [4,5].

The aim of revascularization is to prevent amputation and preserve the patient's functional status in order to facilitate independent living [6]. However, modern advances in revascularization procedures have not reflected clearly on the frequency of major LEA [7–9]. The frequency of major LEA in the U.S. between 2007 and 2009 was 89 per 100,000 in > 65 year old Medicare patients [10]. A more recent Danish study reported annual rates of amputation from 2002 to 2014 to range from approx. 70 to 130 per 100,000 patients over 50 years old [11]. Substantial differences in the frequency of major LEA and rates of vascular procedures across different regions of countries were reported in both studies [10,11]. The frequency of usage of major LEAs in Finland decreased by 41% from 1984 to 2000 and an inverse correlation between amputation frequency and infrainguinal bypass was found [12].

Vascular registries revealed large numbers of open revascularization procedures compared to endovascular procedures in Finland during the 1990s [13,14]. A similar trend in revascularization procedures was reported from 1998 to 2002 when the frequency of amputation in Finland was 15.4–24.1 per 100,000 person years [12,15]. Since then

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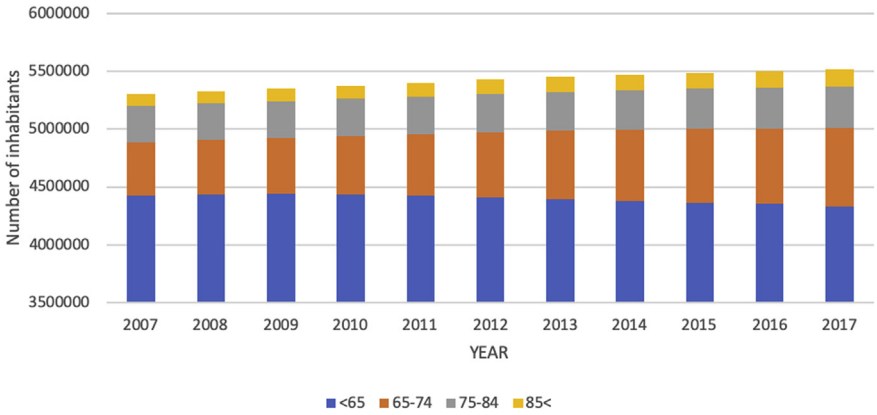

Fig. 1. Number of inhabitants in Finland by age groups for 2007 to 2017 inclusive, according to the StatFin database.

there has been advancement and an increase in revascularization procedures in western countries. The number of endovascular procedures has especially increased [11,16–18].

The aim of this study was to assess the national vascular workload in Finland over the 11-year study period of 2007–2017 and analyze whether the numbers and types of vascular procedures have had an effect on the frequency of usage of major LEA.

2. Material and methods

2.1. Study setting

This is a nationwide public registry data-based study.

2.2. Study data

Statistics Finland is a Finnish public government authority specifically established for statistics. StatFin is an online database governed by Statistics Finland (https://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/). StatFin database utilized for background data for this study, concerning the age and gender distribution of the Finnish population between 2007 and 2017.

The Finnish National Institute for Health and Welfare (THL) is a state funded research organization that functions under the auspices of the Social Affairs and Health political ministry. THL database includes nationwide data concerning treatment periods and procedures performed by official healthcare providers in Finland. The official healthcare providers include the public and the private healthcare providers. The THL data are coded according to the ICD-10 coding system. A data search of the THL registry concerning the annual numbers of all major amputations and revascularization procedures between 2007 and 2017 was performed.

Open revascularization procedures were divided into four categories (with sub-categories in parenthesis) according to the level of revascularization: aorto-iliac revascularization (PDH), femoro-popliteal revascularization (PEE, PEF, PEN, PEH), tibial revascularization (PFA, PFN, PFH) and extra-anatomic bypass procedures (PGH). Similarly, the endovascular procedures were divided into iliac (PD3AT, PD3BT, PD3YT), femoro-popliteal (PE1AT, PE1BT, PE1YT) and tibial procedures (PF1AT, PF1BT and PF1YT). Endovascular procedures included both percutaneous transluminal angioplasty (PTA) and stenting procedures. The above knee amputations (AKA) operation were searched by operation code NFQ20 and below the knee amputations (BKA) by the code NGQ20. Gender and age of all operated patients at the time of index procedure was recorded.

2.3. Statistical methods

Patients were divided into four cohorts (< 65 y, 65–74 y, 75-84y and > 85y) and also based on their respective procedure dates. The annual rates of vascular procedures for each age group were calculated using the number of revascularizations as the numerator and the number of inhabitants in Finland each year in that same age group as the denominator. The age categorized number of vascular operations per 100,000 inhabitants was reported as rates and the frequencies of amputations are presented as numbers per 100,000 inhabitants for the defined age group.

Associations between patient counts and time were studied using regression analysis. Analyses were performed separately for all age groups. The normality assumption was checked using standardized residuals. Statistical analyses were performed using SPSS™, version 25 (IBM SPSS Statistics for Windows, IBM Corporation, Armonk, NY).

2.4. Ethical considerations

The THL registry is a public registry. The data search from the registry was registered in www.researchregistry.com and was assigned a UIN (researchregistry5106). No information that can be linked to individual patients or hospitals was acquired. No ethics committee permission was needed. The work has been reported in line with the STROCSS criteria [19].

3. Results

According to the StatFin database, Finnish population has grown from 5,300,484 in 2007 to 5,513,130 in 2017. An increase in the proportion of the people over 65 years occurred. The age distribution of the Finnish population is illustrated in Fig. 1.

3.1. Revascularizations

Between 2007 and 2017, a total of 69,523 revascularization procedures were performed in Finland. The total number of revascularization procedures increased from 3496 operations in 2007–9506 operations in 2017.

The annual rate of vascular procedures in Finland increased from 66 to 172 ($P < 0.01$). The mean increase was 10 procedures per year (95% CI 8.6–12.3, $P < 0.01$). The age standardized number of vascular operations per 100,000 inhabitants increased in all age groups. The growth was the most significant (2.5x) in patients over 85 years old (Fig. 2).

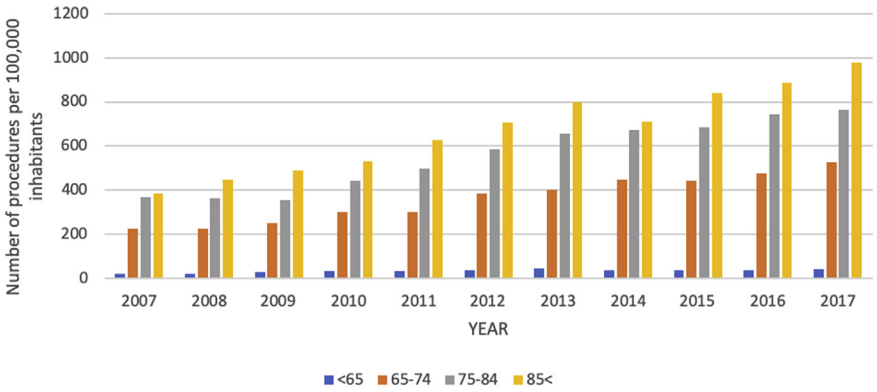

Fig. 2. The annual rates of vascular procedures.

3.2. Open revascularizations

The total number of open revascularizations increased from 2705 operations in 2007–3992 operations in 2017. The mean annual increase for open revascularizations was 141 operations (95% CI 110–174, $P < 0.01$) between 2007 and 2017. The increase of open revascularizations was most evident in younger patients (< 65 years) until 2013, followed by the 65–74-year-old patients cohort (Fig. 3).

Considerable differences in the numbers of procedures in different arterial segments were observed during the study period (Fig. 4a–c). The number aorto-iliac bypass procedures decreased (annual decrease 11 per year, 95% CI -14 to −7, $P < 0.01$) as did the number of extra-anatomic bypass procedures (annual decrease 8 per year, 95%CI -10 to −5, $P < 0.01$) (Fig. 4a). For the femoro-popliteal segment, the numbers of femoral endarterectomies grew (annual increase 168 per year, 95% CI 139–195, $P < 0.01$ at the same time the numbers of femoro-popliteal bypass procedures remained constant (annual decrease 3 per year 95% CI -10 to 5, $P = 0.39$) (Fig. 4b). The numbers of tibial bypass procedures also decreased slightly (annual decrease 4 per year, 95% CI -8 to 0. $P = 0.03$ (Fig. 4c).

3.3. Endovascular revascularizations

The total numbers of endovascular revascularization procedures were 791 operations in 2007 and 5514 operations in 2017. The mean annual increase for endovascular procedures was 491 (95% CI 433–550, $P < 0.01$) between 2007 and 2017. The proportion of endovascular of all revascularization procedures increased from 22.6% in 2007 to 60.5% in 2017. Endovascular procedures increased steadily for all age groups (Fig. 5).

A considerable increase in endovascular revascularization procedures was seen in all vascular segments. For the aorto-iliac segment an annual increase was 154 procedures per year, 95% CI 129–178, $P < 0.01$), for femoro-popliteal (annual increase 229 per year, 95% CI 195–260, $P < 0.01$) and for tibial (annual increase 113 per year, 95% CI 94–131, $P < 0.01$). Fig. 6a–c.

In order to further understand the segment dependent use of primary stenting and PTA procedures, the endovascular procedures were further analyzed. The number of reported primary stenting procedures increased from 0 in 2007 to 1810 in 2017. This increase has been most evident in the aorto-iliac segment where primary stenting has become the first line of therapy, in 2017,997 (62.7%) iliac artery lesion were treated with primary stenting. A growing percentage of femoropopliteal lesions are also being treated with primary stenting. In 2017,777 (29.9%) femoropopliteal lesions were treated with primary stenting. In the tibial segment PTA has remained the first line of therapy. Table 1.

3.4. Major LEAs

During the 11-year study period 11,851 major LEAs were performed in Finland (Fig. 7.). The annual frequency of major LEA in the whole Finnish population was 18–20 during 2007–2017. The mean frequency of amputations was 42 in 65–74y old patients, 103 in 75–84y old patients and 233 in > 85y old patients.

When 65–74, 75–84 and 85 < cohorts were pooled together the frequency on amputations decreased from 93 to 72 during 2007–2017 ($P < 0.03$). The reduction in the frequency was most evident in the oldest age group, 262 in 2007, which decreased to 185 in 2017 (> 85 years). The frequency of amputations in each age group is illustrated in Fig. 8.

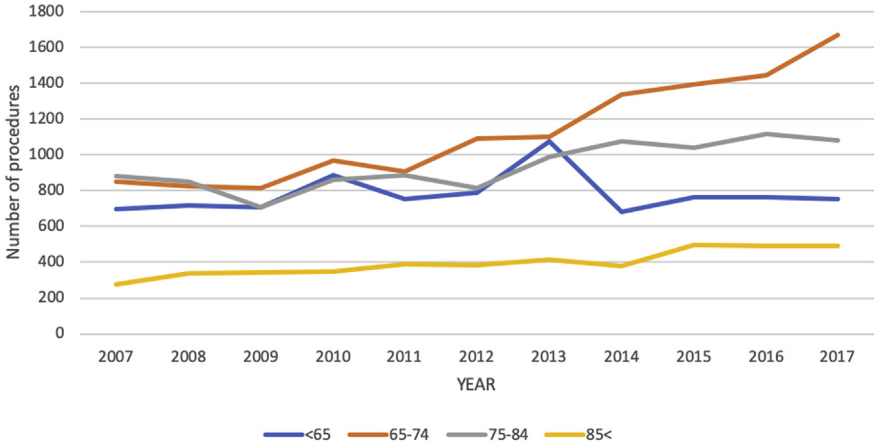

Fig. 3. Open revascularization procedures by age groups 2007 and 2017 in Finland. A total of 35,633 open operations were performed.

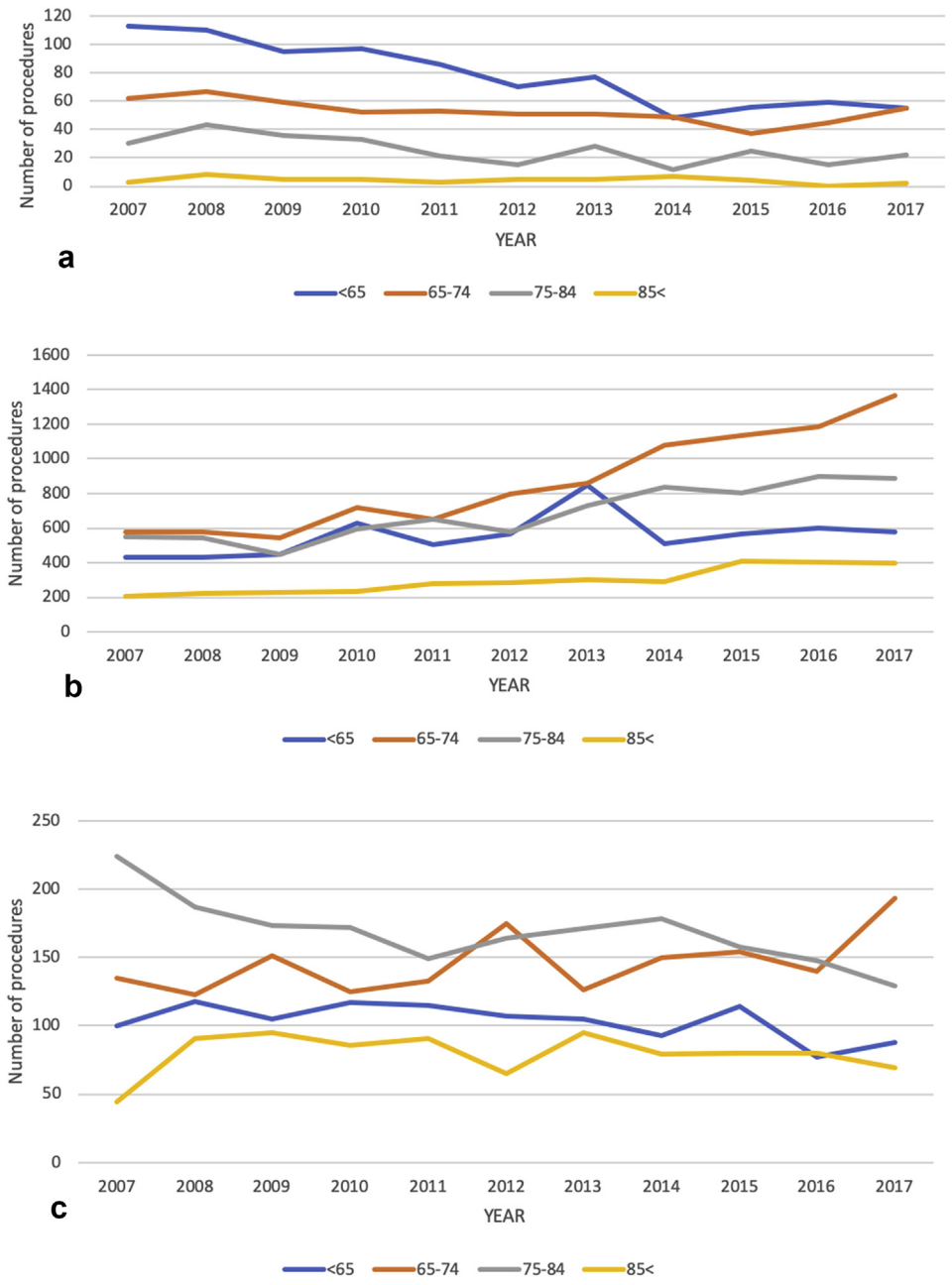

Fig. 4. a. Numbers of aorto-iliac bypass procedures by age groups over 2007 and 2017 in Finland. A total of 1774 aortoiliac open operations were performed. b. Numbers of revascularization operations to the femoropopliteal segment by age groups between 2007 and 2017 in Finland. A total of 26,382 open femoropopliteal operations were performed. c. Numbers of tibial bypass procedures by age groups between 2007 and 2017 in Finland A total of 5472 tibial bypass operations were performed.

4. Discussion

The present study demonstrated an increase in the rates of vascular procedures in Finland between 2007 and 2017. This is especially due to an increase of endovascular procedures and also but to a lesser extent due to an increase of open surgical revascularizations. A clear decrease in the frequency of major LEAs in the older age groups was evident for the same period.

Many other factors besides revascularization procedures determine the fate of the limb [7,20–22]. Moreover, it has been reported that the increased number of revascularization procedures reflects the number of major amputations [10,23]. The rate of major amputation, and also amputation free survival after vascular procedures remain quality measures of peripheral vascular surgery [6]. On the other hand, our clinical experience is that a proportion of the patients that undergo major LEA are judged to be too ill or have such severely reduced functional ability that no revascularization attempts can be made prior to amputation.

The FinnVasc registry data from the early nineties (1991–1994) showed the frequency of major LEA to be 21.6 and the rate of vascular procedures 20.3 per 100,000 inhabitants per year in Finland [23]. A 20–30 fold regional difference in the rate of infrapopliteal procedures was noted in Finland, and this was inversely correlated with a high incidence on amputation [23]. Our present study data show that the annual intensity of vascular procedures for the Finnish population increased significantly, from 66 to 172. The increase in open surgical revascularization rate was most evident in 65–74y old patients, endovascular procedures increased for all age groups. Over the same time

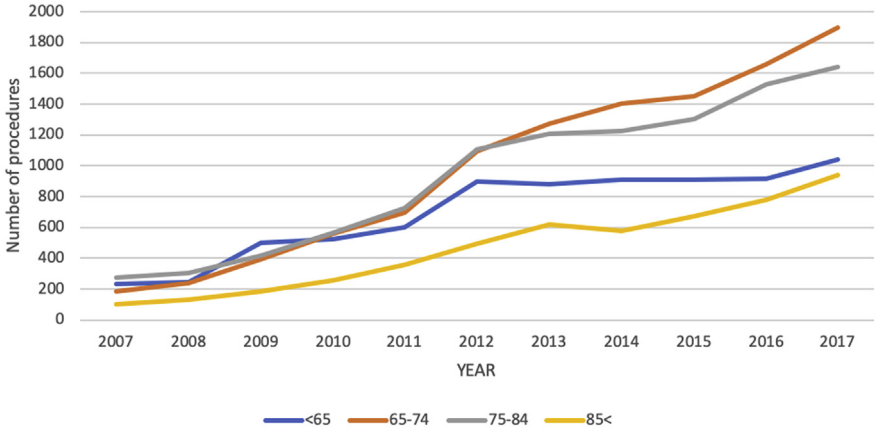

Fig. 5. Numbers of endovascular revascularization procedures by age groups between 2007 and 2017 in Finland. Altogether 33,890 endovascular procedures were performed.

period, the annual frequency of major LEA in the Finnish population was 18–20, with a considerable decreasing trend in the number of major LEA in the oldest patients.

When comparing present data with the FinnVasc registry one must keep in mind that the population has grown older demographically and the percentage of the oldest age groups in the population has increased. The increased incidence of PAD in healthcare systems in western countries has resulted in increased vascular workload, in order to maintain the LEA levels constant.

The development of new endovascular techniques recently has been overwhelming. This has guided the vascular treatments towards a more endovascular direction. For example, according to the FinnVasc registry study of 1991–1994 the proportions of open to endovascular procedures were 68.5% of vascular procedures were open and 32% were endovascular [14]. According to our present data in 2007 endovascular procedures still accounted for only 22.6% of all revascularization procedures in Finland. A rapid increase of endovascular procedures however, was noted in our study and in 2017 up to 60.5% of all revascularization were endovascular.

The present study also showed that the shift towards an endovascular approach was most apparent for the aorto-iliac segment, a simultaneous decline in aorto-iliac surgery was noted. The endovascular treatment of the femoro-popliteal segment increased considerably. It has earlier been reported that patients with intermittent claudication might be offered a less invasive treatment [24]. The numbers of femoropopliteal bypass procedures remained relatively constant, but there was a clear increase in femoral endarterectomies. Hybrid procedures with a femoral endarterectomy combined with a femoro-popliteal endovascular procedure might have resulted in this change.

The numbers of tibial bypass procedures showed a minor decrease. This is evident in the older population by a growing number of endovascular procedures that corresponded to the other western countries [9,25,26]. Since patients with severe tibial atherosclerosis have multiple co-morbidities, they are judged too ill for bypass surgery and an endovascular treatment with less perioperative complications is often selected for first line revascularization [27,28]. On the other hand, endovascular interventions might often require several redo-procedures, which will lead to a large number of procedures [29,30].

Existing randomized trials that compare endovascular and surgical revascularization have not provided a consensus about the recommended strategy for revascularization for PAD [31–35]. Two additional randomized trials (BEST-CLI and ROBUST) are now enrolling patients in order to provide a resolution to this question. Current practice is based on the BASIL trial, which demonstrated better long-term results with open revascularization [31]. In contrast to this, some earlier studies reported better limb survival after endovascular revascularization [17]. This might have also led some vascular physicians in Finland to advocate an “endovascular first” strategy [36–39], however there are some recent studies that oppose this approach [40].

4.1. Study limitations

This is a registry based “big data” study, however it has several limitations. The registry does not contain information about the patients on an individual level. The outcome of individual procedures cannot be evaluated. Moreover, these data do not allow any analyses on the association between the time of the revascularization and major amputation. The patients that had undergone major LEA were not the same patients that had been revascularized. The primary and secondary procedures cannot therefore be differentiated. Nevertheless, this is a national country-wide registry and is representative of the extensive public health sector of a developed European country.

4.2. Conclusion

The present study demonstrated an increase in the need for vascular surgery work during 2007–2017 an 11-year period. The increase was most evident in the endovascular procedures. During the same period there was a significant decrease in the frequency of major LEAs in 65 years.

Ethical approval

The registry that was used is a public registry. No information that can be linked to individual patients or hospitals was acquired. No ethics committee permission was needed.

Sources of funding

There is no funding for this project/research.

Research registration number

Name of the registry: www.researchregistry.com.
Unique Identifying number or registration ID: researchregistry5106.
Hyperlink to the registration (must be publicly accessible): https://www.researchregistry.com/browse-the-registry#home/

Guarantor

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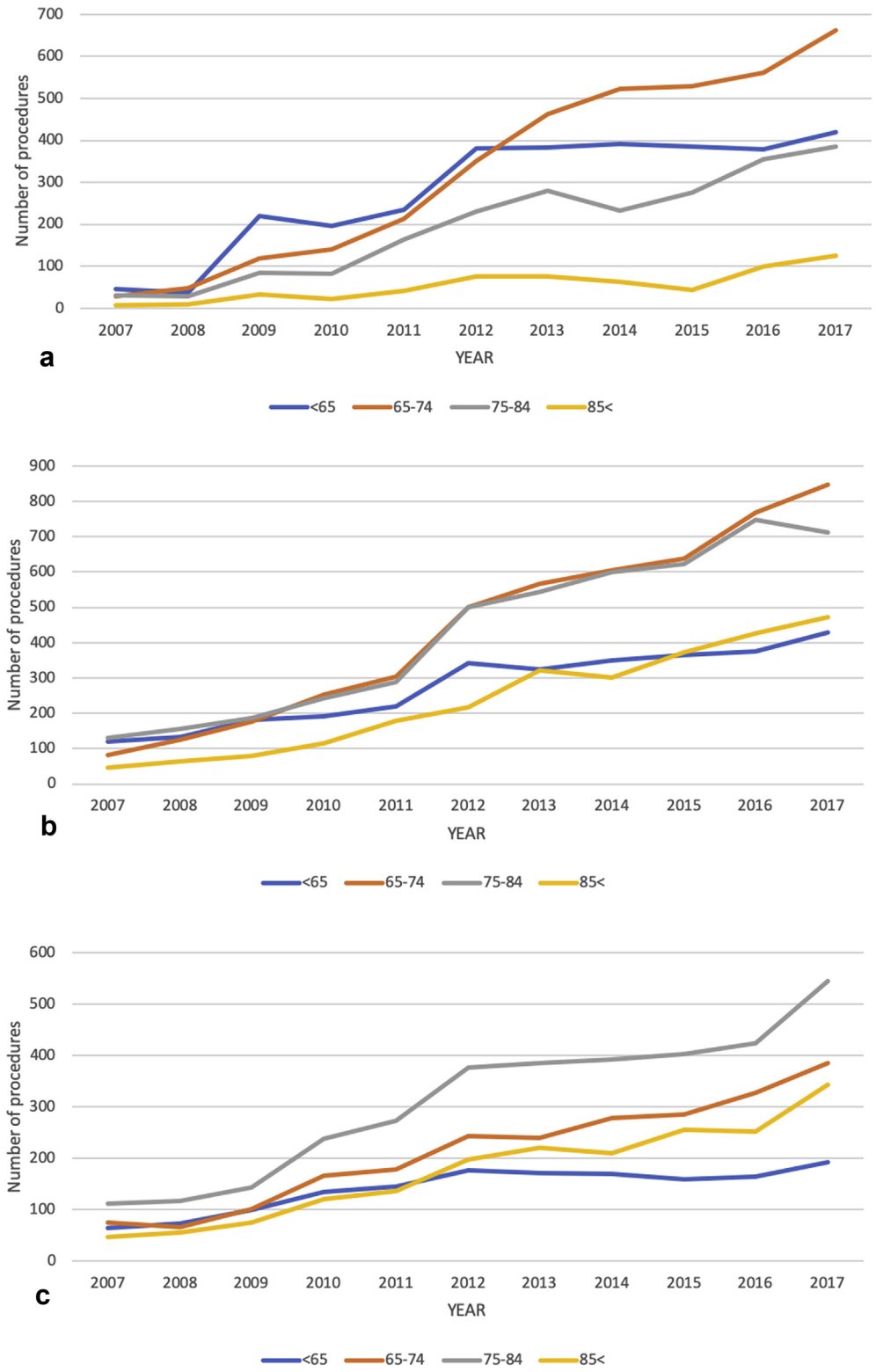

Fig. 6. a. Numbers of aorto-iliac endovascular procedures by age groups between 2007 and 2017 in Finland. A total of 9442 aorto-iliac endovascular procedures were performed. b. Numbers of femoropoliteal endovascular procedures by age groups between 2007 and 2017 in Finland. A total of 15,225 femoropopliteal endovascular procedures were performed. c. Numbers of tibial bypass endovascular procedures by age groups between 2007 and 2017 in Finland. A total of 9223 tibial endovascular operations were performed.

Table 1
Numbers of PTA and stenting procedures in different arterial segments.

YEAR	PTA N (%)	STENTING N (%)	ALL N	PTA N (%)	STENTING N (%)	ALL N	PTA N (%)	STENTING N (%)	ALL N
	Aorto-iliac			Femoro-popliteal			Tibial		
2007	108 (100.0)	0 (0.0)	108	389 (100.0)	0 (0.0)	389	300 (100.0)	0 (0.0)	300
2008	98 (100.0)	0 (0.0)	98	479 (100.0)	0 (0.0)	479	313 (100.0)	0 (0.0)	313
2009	251 (53.3)	220 (46.7)	471	526 (84.3)	98 (15.7)	624	418 (100.0)	0 (0.0)	418
2010	264 (60.0)	176 (40.0)	440	688 (85.8)	114 (14.2)	802	659 (100.0)	0 (0.0)	659
2011	286 (48.1)	308 (51.9)	594	824 (83.1)	167 (16.9)	991	732 (100.0)	0 (0.0)	732
2012	471 (45.4)	566 (54.6)	1037	1188 (76.2)	371 (23.8)	1559	986 (99.5)	5 (0.5)	991
2013	505 (42.1)	695 (57.9)	1200	1300 (73.9)	458 (26.1)	1758	1006 (98.8)	12 (1.2)	1018
2014	478 (38.3)	773 (61.7)	1251	1352 (72.8)	504 (27.2)	1856	1037 (98.8)	13 (1.2)	1050
2015	464 (36.1)	822 (63.9)	1286	1413 (70.7)	585 (29.3)	1998	1089 (98.6)	15 (1.4)	1104
2016	523 (37.5)	870 (62.5)	1393	1632 (70.3)	687 (29.7)	2319	1161 (98.9)	13 (1.1)	1174
2017	592 (37.3)	997 (62.7)	1589	1798 (69.8)	777 (30.2)	2575	1430 (97.5)	36 (2.5)	1466

PTA = percutaneous transluminal angioplasty.

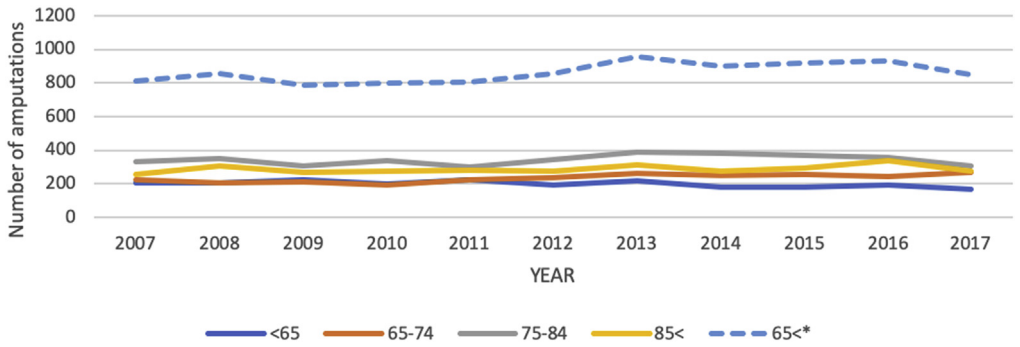

Fig. 7. Numbers of major lower extremity amputations by age groups for 2007 and 2017 period in Finland. A total of 11,851 amputations were performed.

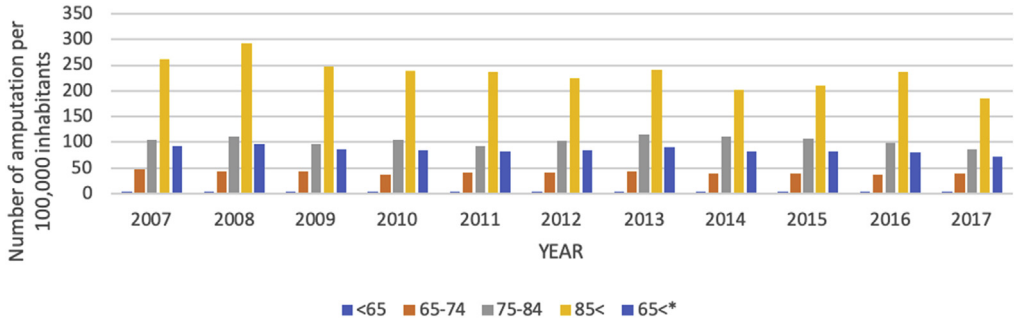

Fig. 8. Amputation frequency in different age groups for the 2007 to 2017 period.

Provenance and peer review

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Funding/support

No outside funding was received for this study.

Data statement

The THL registry is a public registry. No information that can be linked to individual patients or hospitals was acquired. The THL registry was searched 3.6.2019.

CRediT authorship contribution statement

Veikko Nikulainen: Data curation, Formal analysis, Writing - original draft, Writing - review & editing. **Päivi Helmiö:** Writing - original draft, Writing - review & editing. **Harri Hakovirta:** Investigation, Methodology, Project administration, Writing - original draft, Writing - review & editing.

Declaration of competing interest

There are no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijsu.2019.10.039.

References

[1] M.M. McDermott, The magnitude of the problem of peripheral arterial disease: epidemiology and clinical significance, Clevel. Clin. J. Med. 73 (Suppl 4) (2006 Oct) S2–7.

[2] R. Nowygrod, N. Egorova, G. Greco, P. Anderson, A. Gelijns, A. Moskowitz, et al.,

Trends, complications, and mortality in peripheral vascular surgery, J. Vasc. Surg. 43 (2) (2006 Feb) 205–216.
[3] B. Sigvant, K. Wiberg-Hedman, D. Bergqvist, O. Rolandsson, B. Andersson, E. Persson, et al., A population-based study of peripheral arterial disease prevalence with special focus on critical limb ischemia and sex differences, J. Vasc. Surg. 45 (6) (2007 Jun) 1185–1191.
[4] L. Norgren, W.R. Hiatt, J.A. Dormandy, M.R. Nehler, K.A. Harris, F.G.R. Fowkes, et al., Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC II), (2007), pp. S5–S67.
[5] G.A. Carmona, P. Hoffmeyer, F.R. Herrmann, J. Vaucher, O. Tschopp, A. Lacraz, et al., Major lower limb amputations in the elderly observed over ten years: the role of diabetes and peripheral arterial disease, Diabetes Metab. 31 (5) (2005 Nov) 449–454.
[6] S.M. Taylor, C.A. Kalbaugh, D.W. Blackhurst, A.L. Cass, E.A. Trent, E.M. Langan, et al., Determinants of functional outcome after revascularization for critical limb ischemia: an analysis of 1000 consecutive vascular interventions, J. Vasc. Surg. 44 (4) (2006 Oct) 747–755 discussion755–6.
[7] S.K. Shah, J.F. Bena, M.T. Allemang, R. Kelso, D.G. Clair, L. Vargas, et al., Lower extremity amputations: factors associated with mortality or contralateral amputation, Vasc. Endovasc. Surg. 47 (8) (2013 Nov) 608–613.
[8] P.W. Moxey, P. Gogalniceanu, R.J. Hinchliffe, I.M. Loftus, K.J. Jones, M.M. Thompson, et al., Lower extremity amputations–a review of global variability in incidence, Diabet. Med. 28 (10) (2011 Oct) 1144–1153 John Wiley & Sons, Ltd (10.1111).
[9] P.W. Moxey, D. Hofman, R.J. Hinchliffe, K. Jones, M.M. Thompson, P.J.E. Holt, Trends and outcomes after surgical lower limb revascularization in England, Br. J. Surg. 98 (10) (2011 Oct) 1373–1382 John Wiley & Sons, Ltd.
[10] P.P. Goodney, K. Holman, P.K. Henke, L.L. Travis, J.B. Dimick, T.A. Stukel, et al., Regional intensity of vascular care and lower extremity amputation rates, J. Vasc. Surg. 57 (6) (2013 Jun) 1471–1479 1480.e1–3–discussion1479–80.
[11] L.S. Londero, A. Høgh, K. Houlind, J.S. Lindholt, Danish trends in major amputation after vascular reconstruction in patients with peripheral arterial disease 2002-2014, Eur. J. Vasc. Endovasc. Surg. 57 (1) (2019 Jan) 111–120.
[12] E. Eskelinen, M. Lepäntalo, E.-M. Hietala, H. Sell, L. Kauppila, I. Mäenpää, et al., Lower limb amputations in Southern Finland in 2000 and trends up to 2001, Eur. J. Vasc. Endovasc. Surg. 27 (2) (2004 Feb) 193–200.
[13] J.P. Salenius, National vascular registry in Finland–FINNVASC. FINNVASC study group, Ann. Chir. Gynaecol. 81 (2) (1992) 257–260.
[14] J.P. Salenius, M. Lepäntalo, K. Ylönen, M. Luther, Treatment of peripheral vascular diseases–basic data from the nationwide vascular registry FINNVASC, Ann. Chir. Gynaecol. 82 (4) (1993) 235–240.
[15] L. Remes, R. Isoaho, T. Vahlberg, H. Hiekkanen, K. Korhonen, M. Viitanen, et al., Major lower extremity amputation in elderly patients with peripheral arterial disease: incidence and survival rates, Aging Clin. Exp. Res. 20 (5) (2008 Oct) 385–393.
[16] N.N. Egorova, S. Guillerme, A. Gelijns, N. Morrissey, R. Dayal, J.F. McKinsey, et al., An analysis of the outcomes of a decade of experience with lower extremity revascularization including limb salvage, lengths of stay, and safety, J. Vasc. Surg. 51 (4) (2010 Apr) 878–885–885.e1.
[17] H.H. Dosluoglu, P. Lall, L.M. Harris, M.L. Dryjski, Long-term limb salvage and survival after endovascular and open revascularization for critical limb ischemia after adoption of endovascular-first approach by vascular surgeons, J. Vasc. Surg. 56 (2) (2012 Aug) 361–371.
[18] P.P. Goodney, A.W. Beck, J. Nagle, H.G. Welch, R.M. Zwolak, National trends in lower extremity bypass surgery, endovascular interventions, and major amputations, J. Vasc. Surg. 50 (1) (2009 Jul) 54–60.
[19] R.A. Agha, M.R. Borrelli, M. Vella-Baldacchino, R. Thavayogan, D.P. Orgill, STROCSS Group, The STROCSS statement: strengthening the reporting of cohort studies in surgery, Int. J. Surg. 46 (2017 Oct) 198–202.
[20] E.P. Vamos, A. Bottle, A. Majeed, C. Millett, Trends in lower extremity amputations in people with and without diabetes in England, Diabetes Res. Clin. Pract. 87 (2) (2010 Feb) 275–282 1996-2005.
[21] M.R. Corey, J. St Julien, C. Miller, B. Fisher, S.L. Cederstrand, W.A. Nylander, et al., Patient education level affects functionality and long term mortality after major lower extremity amputation, Am. J. Surg. 204 (5) (2012 Nov) 626–630.
[22] C.A. Durham, M.C. Mohr, F.M. Parker, W.M. Bogey, C.S. Powell, M.C. Stoner, The impact of socioeconomic factors on outcome and hospital costs associated with femoropopliteal revascularization, J. Vasc. Surg. 52 (3) (2010 Sep) 600 6–discussion606–7.
[23] M. Luther, I. Kantonen, M. Lepäntalo, J. Salenius, FINNVASC Study Group, Arterial intervention and reduction in amputation for chronic critical leg ischaemia, Br. J. Surg. 87 (4) (2000 Apr) 454–458 John Wiley & Sons, Ltd.
[24] W.B. Keeling, P.A. Stone, P.A. Armstrong, H. Kearney, L. Klepczyk, E. Blazick, et al., Increasing endovascular intervention for claudication: impact on vascular surgery resident training, J. Endovasc. Ther. 13 (4) (2006 Aug) 507–513 SAGE PublicationsSage CA: Los Angeles, CA.
[25] F. Liistro, S. Grotti, G. Venturuzzo, P. Angioli, F. Turini, K. Ducci, et al., [Clinical outcome of percutaneous revascularization by stent-assisted balloon angioplasty of femoro-popliteal and tibial vessels in diabetic patients with critical limb ischemia], G. Ital. Cardiol. 10 (11–12) (2009 Nov) 713–717.
[26] C.C.F. Werneck, T.F. Lindsay, Tibial angioplasty for limb salvage in high-risk patients and cost analysis, Ann. Vasc. Surg. 23 (5) (2009 Sep) 554–559.
[27] J.M. Jalkanen, J.E. Wickström, M. Venermo, H.H. Hakovirta, The extent of Atherosclerotic lesions in crural arteries predicts survival of patients with lower limb peripheral artery disease: a new classification of crural atherosclerosis, Atherosclerosis 251 (2016 Aug) 328–333.
[28] C.W. Hicks, J.K. Canner, Y.W. Lum, J.H. Black 3rd, C.J. Abularrage, Long-term outcomes of an endovascular-first approach for diabetic patients with predominantly tibial disease treated in a multidisciplinary setting, Ann. Vasc. Surg. (2019 Oct) 315–326.
[29] H.E. Baer-Bositis, T.D. Hicks, G.M. Haidar, M.J. Sideman, L.L. Pounds, M.G. Davies, Outcomes of reintervention for recurrent symptomatic disease after tibial endovascular intervention, J. Vasc. Surg. 68 (3) (2018 Sep) 811–821.
[30] A. Mohapatra, J.C. Henry, E.D. Avgerinos, A. Boitet, R.A. Chaer, M.S. Makaroun, S.A. Leers, E.S. Hager, Bypass versus endovascular intervention for healing ischemic wounds secondary to tibial arterial disease, J. Vasc. Surg. 68 (3) (2018 Sep) 811–821.
[31] Bypass versus angioplasty in severe ischaemia of the leg (BASIL): multicentre, randomised controlled trial, The Lancet 366 (9501) (2005 Dec) 1925–1934.
[32] A.W. Bradbury, D.J. Adam, J. Bell, J.F. Forbes, F.G.R. Fowkes, I. Gillespie, et al., Bypass versus Angioplasty in Severe Ischaemia of the Leg (BASIL) trial: a survival prediction model to facilitate clinical decision making, J. Vasc. Surg. 51 (5) (2010 May 1) 52S–68S Elsevier.
[33] K. McQuade, D. Gable, S. Hohman, G. Pearl, B. Theune, Randomized comparison of ePTFE/nitinol self-expanding stent graft vs prosthetic femoral-popliteal bypass in the treatment of superficial femoral artery occlusive disease, J. Vasc. Surg. 49 (1) (2009 Jan) 109–15–116.e1–9–discussion116.
[34] E.S. van der Zaag, D.A. Legemate, M.H. Prins, J.A. Reekers, M.J. Jacobs, Angioplasty or bypass for superficial femoral artery disease? A randomised controlled trial, Eur. J. Vasc. Endovasc. Surg. 28 (2) (2004 Aug) 132–137.
[35] J. Kedora, S. Hohmann, W. Garrett, C. Munschaur, B. Theune, D. Gable, Randomized comparison of percutaneous Viabahn stent grafts vs prosthetic femoral-popliteal bypass in the treatment of superficial femoral arterial occlusive disease, J. Vasc. Surg. 45 (1) (2007 Jan) 10–16 discussion16.
[36] N. Hynes, B. Mahendran, B. Manning, E. Andrews, D. Courtney, S. Sultan, The influence of subintimal angioplasty on level of amputation and limb salvage rates in lower limb critical ischaemia: a 15-year experience, Eur. J. Vasc. Endovasc. Surg. 30 (3) (2005 Sep) 291–299.
[37] M. Schillinger, S. Sabeti, P. Dick, J. Amighi, W. Mlekusch, O. Schlager, et al., Sustained benefit at 2 years of primary femoropopliteal stenting compared with balloon angioplasty with optional stenting, Circulation 115 (21) (2007 May 29) 2745–2749 Lippincott Williams & Wilkins.
[38] E. Arvela, M. Venermo, M. Söderström, M. Korhonen, K. Halmesmäki, A. Albäck, et al., Infrainguinal percutaneous transluminal angioplasty or bypass surgery in patients aged 80 years and older with critical leg ischaemia, Br. J. Surg. 98 (4) (2011 Apr) 518–526 John Wiley & Sons, Ltd.
[39] M.I. Söderström, E.M. Arvela, M. Korhonen, K.H. Halmesmäki, A.N. Albäck, F. Biancari, et al., Infrapopliteal percutaneous transluminal angioplasty versus bypass surgery as first-line strategies in critical leg ischemia: a propensity score analysis, Ann. Surg. 252 (5) (2010 Nov) 765–773.
[40] K. Noronen, E. Saarinen, A. Albäck, M. Venermo, Analysis of the elective treatment process for critical limb ischaemia with tissue loss: diabetic patients require rapid revascularisation, Eur. J. Vasc. Endovasc. Surg. 53 (2) (2017 Feb) 206–213.