Surgery 166 (2019) 198–202

Contents lists available at ScienceDirect

Surgery

journal homepage: www.elsevier.com/locate/surg

Vascular

Peripheral arterial occlusive disease operative case volume in the final years of 5+2 and 0+5 vascular training paradigms

John Phair, MD[a,b], Matthew L. Carnevale, MD[a,b], Victoria G. Teveris, MD[c], Issam Koleilat, MD[a,b], Jeffrey E. Indes, MD[a,b,*]

[a] Albert Einstein College of Medicine, Bronx, NY
[b] Division of Vascular Surgery, Montefiore Medical Center, Bronx, NY
[c] Department of Vascular Surgery, Dartmouth-Hitchcock Medical Center, Lebanon, NH

ARTICLE INFO

Article history:
Accepted 28 February 2019
Available online 6 April 2019

ABSTRACT

Background: Peripheral arterial occlusive disease constitutes a substantial portion of clinical practice in vascular surgery and, as such, trainees must graduate with proficiency in endovascular and open procedures to become capable vascular surgeons. Case volume for 0+5 integrated vascular surgery residents in the chief and junior years was compared with their 5+2 fellowship counterparts for the treatment of peripheral arterial occlusive disease.

Methods: In this retrospective review, operative volume for peripheral arterial occlusive disease cases in both vascular training paradigms was evaluated. "Surgeon chief" cases in the final year of residency training, and "surgeon junior" cases for postgraduate year 4 and below were gathered for the integrated vascular surgery residents group. Annual fellow's case volume was collected using cases logged as "surgeon fellow." Procedures were divided by the following anatomic region and compared: aortoiliac, femoropopliteal, and infrapopliteal. Student's *t* tests were used to assess these differences.

Results: An aggregate of 887 residents and fellows from 137 programs were identified. Vascular surgery fellows consistently performed 1.7-fold ($P < .001$) and 1.6-fold ($P < .001$) more total peripheral cases than their integrated vascular surgery residents chief and junior counterparts, respectively. They also performed 1.8-fold ($P = .002$) and 1.5-fold ($P = .004$) more peripheral endovascular cases than their 0+5 chief and junior counterparts respectively. With respect to endovascular treatment of peripheral arterial occlusive disease by subgroup, we found the overall volume of aortoiliac and femoropopliteal increased, whereas infrapopliteal case volume decreased. Vascular surgery fellows were performing many more of these cases per year than the integrated vascular surgery residents chiefs and junior residents. When looking at 3 index open procedures, aortobifemoral bypass, femoropopliteal bypass with vein, and infrapopliteal bypass with vein in the academic year 2017–2018, the vascular surgery fellow trainees performed more cases than the integrated vascular surgery residents chief and junior residents.

Conclusion: Earlier studies have compared the operative volume of vascular surgery fellows and integrated vascular surgery residents in their entire tenure of training. Our study specifically evaluated the years of training that confer the greatest level of autonomy. Vascular surgery fellows are performing more endovascular and open cases than their 0+5 counterparts for peripheral arterial occlusive disease during the final phase of training. These findings suggest that current suspected equipoise of vascular surgery training paradigms may not reflect what is occurring in practice and therefore warrants further investigation.

Introduction

The primary certificate in vascular surgery was approved by the Accreditation Council for Graduate Medical Education (ACGME) in the United States in 2006. This paved the way for the development of integrated (0+5) vascular programs and eliminated the need to be certified in general surgery before obtaining certification and

* Reprint requests: Jeffrey E. Indes, MD, Department of Vascular Surgery, Montefiore Medical Center, 3400 Bainbridge Ave, Medical Arts Pavilion, Floor 4, Bronx, NY 10467.
E-mail address: jindes@montefiore.org (J.E. Indes).

https://doi.org/10.1016/j.surg.2019.02.021
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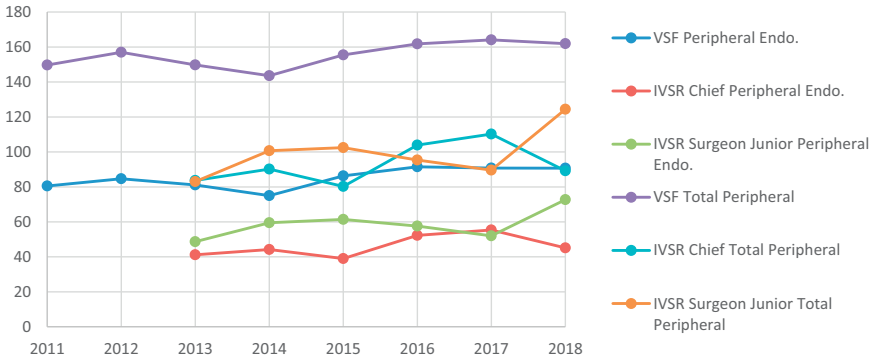

Fig 1. Comparison of total peripheral arterial cases. Total number of logged cases that met criteria plotted per academic year for IVSR chief residents, IVSR residents, and vascular surgery fellows.

training in vascular surgery. Vascular surgery training paradigms have thus evolved into 2 predominant cohorts: the 0+5 integrated residency (IVSR) and the 5+2 traditional fellowship (VSF). IVSRs are selected from medical school to complete a 5-year residency in vascular surgery, whereas VSFs have completed 5 years of general surgery and must complete an additional two years of dedicated vascular surgery training. Since the advent of IVSR training in 2007, the total number of vascular residents in training has grown and now outnumbers total VSF trainees in the United States.[1]

Earlier studies have used operative case volume as a surrogate for operative experience and found equivalence in open training between the 2 groups with superior total endovascular training in IVSR.[2,3] As such, the surgical community has had a positive perception of the IVSR graduates despite anecdotal reservations regarding the open operative skills.[4] However, these studies were limited by the method of comparison: The entire experience of IVSR training was compared with the entire 7 years of VSF training, either by evaluating all cases or only vascular procedures inclusive of secondary procedures.

To ensure preparedness for practice, vascular surgery training requires adequate open and endovascular case volume before graduation, given the heterogeneity of approaches and distribution of disease. Therefore, it was the aim of this study to determine whether the chief year of the 0+5 training paradigm is comparable with an equivalent VSF year of training. We compared the IVSR and VSF trainees in total peripheral arterial occlusive disease experience, specifically focusing on their last 12 months of vascular training.

Methods

ACGME case logs between 2012 and 2018 were collected from a pool of 887 residents and fellows from 137 programs in the United States. IVSR ACGME case log data originated with the graduation of the inaugural IVSR classes in 2012. Case log information was extracted from ACGME statistical reports. National average case numbers recorded as performed by the "surgeon chief" were used in this study to selectively review operative volumes in the training period immediately before the completion of training. Surgeon chief was defined as all cases performed by the resident surgeon during the chief year (the 12 months before graduation from training). Junior resident case volume of IVSR was estimated using "surgeon junior" case logs. Unfortunately, cases are not available by postgraduate year and thus junior resident experience is catalogued in the surgeon junior category. Although this category includes trainees in the early stages of their residency, the vast majority of peripheral vascular operations are staffed by senior residents.[5] ACGME reports for VSF do not separate records by junior and senior year of fellowship and thus case log numbers represent 1 year of fellowship training. Therefore, "surgeon fellow" case logs were selected. Only procedures specific to the treatment of peripheral occlusive disease were included. Given that this is publicly available deidentified information, our study was deemed exempt from institutional review board approval.

To determine whether there was a significant difference between the average numbers of cases completed by graduates of each training paradigm, Student's *t* tests were used. Case types that met inclusion criteria were subsequently grouped by anatomic region: aortoiliac (AI), femoropopliteal (FP) and infrapopliteal (IP). Endovascular procedures for peripheral arterial occlusive disease were similarly compared. Data are reported as means and standard deviations.

Table I
Comparison of average total cases performed by VSF and IVSR chiefs (2012–2018)

Procedure performed	VSF	IVSR chief	*P* value
Total PAD	155.4 (7.21)	92.9 (11.7)	< **.001**
Total aortoiliac	36.8 (6.47)	22.1 (8.65)	**.003**
Total femoropoplital	70.4 (10.4)	37.2 (17.8)	**.002**
Total infrapopliteal	48.9 (9.09)	23.5 (6.26	< **.001**
Endovascular aortoiliac	18.6 (6.1)	12.5 (4.27)	**.03**
Endovascular femoropopliteal	34.5 (8.83)	18.7 (4.99)	**.002**
Endovascular infrapopliteal	31.9 (10.15)	22.6 (8.02)	**.04**
Open aortoiliac	16.6 (0.72)	11.25 (1.15)	**.005**
Open femoropopliteal	33.84 (1.05)	23.92 (3.05)	**.001**
Open infrapopliteal	19.93 (0.66)	11.55 (1.79)	**.003**

PAD, peripheral arterial disease.

Results

During the period 2012 to 2018, the number of accredited 0+5 programs increased from 10 to 55. There were 158 IVSR trainees in 55 programs from the first ACGME case log in 2012 until 2018. Meanwhile, the number of accredited vascular fellowships remained relatively consistent, with 105 programs during that period. Concurrently, there were 729 VSF trainees from 105 programs. A total of 45 institutions had both IVSR and VSF programs.

From 2012 to 2018, VSFs performed significantly more total peripheral procedures than IVSR surgeon chiefs in the treatment of peripheral arterial occlusive disease (Fig 1). When stratified by anatomic location, VSFs were found to have performed more peripheral arterial procedures in the AI, FP, and IP arteries compared with IVSR chiefs (Table I). VSFs also performed more total peripheral procedures than IVSR surgeon juniors (Table II). In the

Table II
Comparison of average total cases performed by VSF and IVSR surgeon junior (2012–2018)

Procedure performed	VSF	IVSR surgeon junior	*P* value
Total PAD	155.4 (7.21)	99.2 (14.3)	< **.001**
Total aortoiliac	(36.8 (6.47)	19.85 (6.55)	**.001**
Total femoropoplital	(70.4 (10.4)	45.1 (9.47)	**.003**
Total infrapopliteal	(48.9 (9.09)	34.4 (6.02)	< **.001**
Endovascular aortoiliac	18.6 (6.1)	11.9 (5.34)	**.03**
Endovascular femoropopliteal	34.5 (8.83)	21.1 (2.86)	**.004**
Endovascular infrapopliteal	31.9 (10.15)	22.6 (8.02)	**.04**
Open aortoiliac	16.6 (0.72)	7.86 (1.86)	**.009**
Open femoropopliteal	33.84 (1.05)	22.26 (3.60)	**.001**
Open infrapopliteal	19.93 (0.66)	10.48 (1.29)	**.002**

PAD, peripheral arterial disease.

most recent year, fellows performed an average of 161.9 total related procedures, and IVSR chiefs performed 89.2, and IVSR surgeon juniors performed 124.4. This trend was consistent with the preceding years. When considering endovascular treatment of peripheral occlusive disease between VSF and IVSR chiefs, a 2-fold difference was observed in 2018 (90.7 vs 45.1). This trend was also consistent with the preceding years and was mirrored across all 3 anatomic locations assessed

The difference between VSF and both IVSR chiefs and IVSR surgeon juniors was assessed in terms of endovascular and open procedures of the lower extremities (Fig 2). Operative volume of VSF surpassed the volume of IVSR for endovascular procedures. This was true across all three anatomic locations assessed. Open surgical bypass procedures of the lower extremity were also compared between both training paradigms (Fig 2). Once again, VSF operative volume far exceeded the corresponding exposure than IVSR had.

Three common index open bypass procedures, aortobifemoral bypass, femoropopliteal bypass with vein and infra-popliteal bypass with vein performed in the most recent academic year (2018) were compared. VSF trainees performed significantly more cases than the 0+5 residents, respectively (aortobifemoral bypass: 7.8 vs 5.5, femoropopliteal bypass with vein: 10 vs 4.9, infrapopliteal bypass with vein: 15.4 vs 8.2 [Fig 2]). Introducing case log data from junior residents did not make up for the clear discrepancy between IVSR chief experience and VSF experience. In the last academic year, VSF logged an average of 162 peripheral cases each, and IVSR chief and IVSR junior residents logged 89 and 124 peripheral cases, respectively (Fig 3). This amounts to more than 110 fewer cases that IVSRs in their senior years will have logged compared with corresponding VSFs.

Discussion

The evolution of vascular surgery has led to the development of two predominant training paradigms: the traditional vascular surgery fellowship and the integrated vascular surgery residency. Regardless of the path taken, vascular surgeons today must be proficient in both open and endovascular techniques. Although data are sparse regarding this concern, it is not unreasonable to assert that a treatment bias may occur and comfort levels in performing specific procedures may differ, whether open, endovascular, or hybrid. Sufficient experience in the breadth of vascular surgical approaches during training is important for ensuring adequate proficiency and competent graduates. Otherwise, procedural preference attributed to “comfort,” which may not always be the most optimal clinical solution, may develop in graduates from either paradigm.

We found that when comparing the numbers of procedures performed by vascular trainees for the treatment of peripheral arterial occlusive disease, VSFs consistently performed more procedures than their IVSR counterparts. This trend was true and consistent across the three main categories of disease distribution of AI, FP, and IP. In addition, this trend persisted when only comparing endovascular procedures. Finally, when comparing three common index open operations, VSFs consistently performed more of these procedures than IVSRs. The number of open procedures performed by all trainees was lower than expected, possibly reflecting the growing trend toward endovascular-first approaches to peripheral occlusive disease.

According to ACGME guidelines, the final year of integrated training—postgraduate year 5 (PGY-5)—must consist of 12 months of chief resident-level responsibility on a vascular surgery service.[6] The preceding years may include various other surgical rotations; however, the senior years are typically spent almost entirely doing vascular surgery as well. ACGME guidelines also stipulate that residents in an integrated program should perform a minimum of 500 operations, including 250 major vascular reconstructive procedures.[6] One might expect operative volume to be lower in the final year of training because graduating trainees may take time to interview with prospective employers, leading to lower case log numbers. However, when including case log data of junior residents, the difference still exists, with VSFs maintaining higher case volume than their equivalent senior residents.

The methodologic approach in this study was unique compared with earlier studies. The aim was to focus on case volumes specific to the portion of vascular training during which trainees are likely to have the most autonomy and the time nearest to training completion. Indeed, earlier studies have compared total case volumes between paradigms.[3,7,8] Still, our data show that the average numbers of peripheral arterial occlusive disease cases performed by surgeon chiefs in their final year of IVSR training are lower than would be expected.

During the past 2 decades, there has been an increase in endovascular peripheral interventions and a concomitant decrease in open peripheral procedures.[8] Schanzer et al[9] described an increase in ACGME logged total vascular cases attributed largely to an increase in endovascular procedures by residents from 2001 through 2007. Still, this does not explain the discrepancy in case volume between training paradigms observed herein. Across all categories, IVSR case volume was lower than VSF, including endovascular interventions. In addition, one might expect that cases logged as teaching assistant might make up for the discrepancy between the two training paradigms; however, the average case volume logged under this category was consistently less than one for all procedures considered.

Earlier studies sought to evaluate the variety and average number of cases of IVSRs compared with VSFs.[3] In these studies, VSF surgeon fellow and “secondary procedures” case totals were combined with all vascular cases performed in general surgery residency. The resultant cumulative operative experience may thus be overestimated because the educational benefit of the secondary procedures category is unknown. These studies have typically shown an advantage in the endovascular field for integrated residents. Still, some cases logged by junior residents during their nonchief years may reflect a more observational than participatory role. Although observing a case is important in surgical training, it must be supplemented with real intraoperative participation and autonomy. This is more likely to occur during the senior years including PGY-4 and PGY-5.

Although the cumulative years of IVSR training have been shown to be equivalent in number of cases to VSF training, this finding is confounded by the potential varying levels of

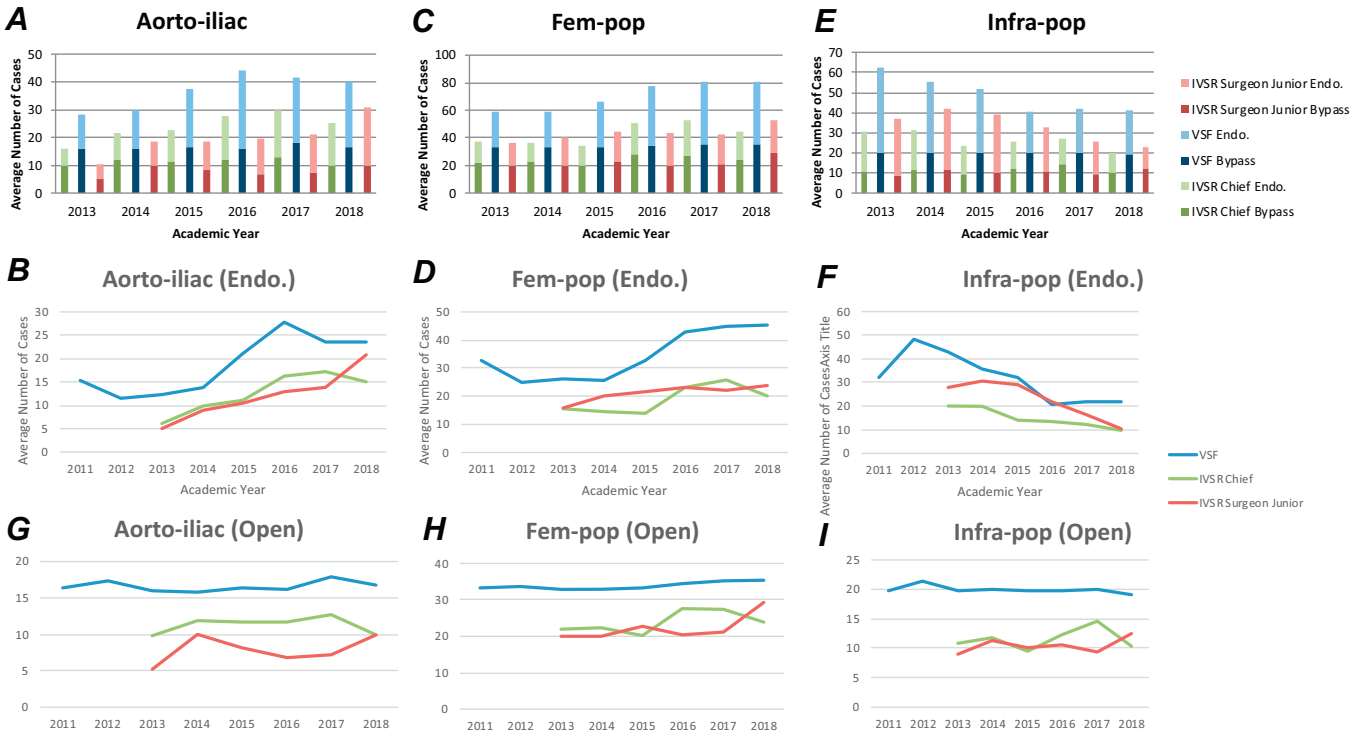

Fig 2. Total number of logged cases plotted per academic year for IVSR chief residents, IVSR residents, and vascular surgery fellows per category. (*A*) Total aortoiliac cases. (*B*) Total endovascular aortoiliac cases. (*C*) Total femoropopliteal cases. (*D*) Total endovascular femoropopliteal cases. (*E*) Total infrapopliteal cases. (*F*) Total endovascular infrapopliteal cases. (*G*) Open aortoiliac cases. (*H*) Open femoropopliteal bypass. (*I*) Open infrapopliteal bypass cases.

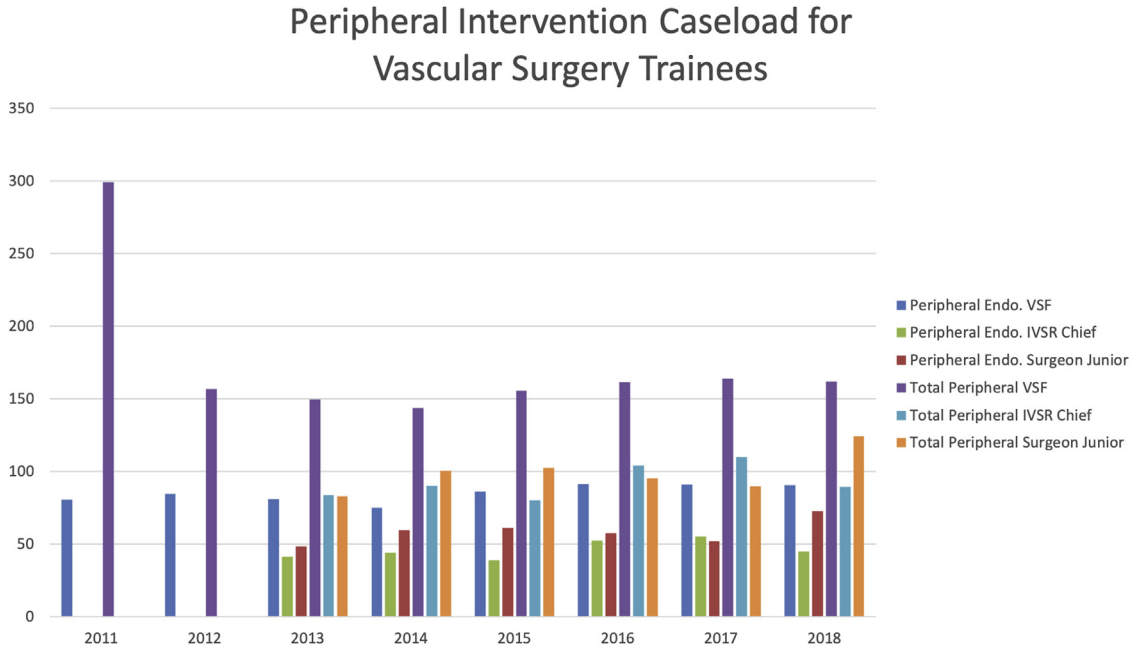

Fig 3. Comparison of the final 2 years of training in both paradigms. Total number of cases logged by IVSR chief residents and IVSR surgeon junior compared with vascular surgery fellows.

participation throughout the years of training, particularly the junior years. Although the use of case volume as a measure of proficiency is not ideal and more cases do not necessarily translate to better outcomes, it is the only objective measure currently available. Experience is typically gained through exposure, and proficiency is reached through repetition. These formative years of training are necessary because "learning to operate also requires developing visual-spatial and tactile skills, as well as the ability to distinguish the pathologic from the normal and to make good judgments, among others. These things are learned by experience, by operating over and over again."[10] Finally, just as the exact influence of cases done in the junior years of vascular training is

unclear, so is the contribution of the cases done in general surgery residency toward the VSF overall training.

Our study is limited by its retrospective nature. The data are obtained from resident reports that may be inaccurate or biased. Residents and fellows are unable to claim credit for more than one procedure, despite the fact that cases may contain multiple independent procedural components. Furthermore, the data are a national average and do not provide information about the distribution of the total cases among specific training programs. As such, exposure may vary widely among individual programs and training paradigms. In addition, if the distribution is not a normal distribution as assumed in our study, the statistical test chosen may in fact lead to inaccurate conclusions. Also, there is insufficient granularity to examine programs with both training models to determine whether this phenomenon is a statistical one simply attributed to national aggregation of data or a true discrepancy. In addition, that fellow logs are not differentiated by year of training limits this study. Finally, the fact that surgeon junior case logs are not catalogued by postgraduate year prevents the addition of PGY-4 cases to the comparison.

It is also certainly possible that our findings actually represent a different distribution of cases over time in the two paradigms. That is to say, IVSRs may have more endovascular experience early in their training with focus on more open procedures in their senior years. In contrast, fellows have limited time (2 years compared with 5 years) and thus the higher numbers are simply reflective of a more concentrated experience. Still, this does not address the potentially large gap in opportunity for intraoperative autonomy.

Unfortunately, there is not enough granularity in the data currently to adequately address the operative volume discrepancy or speculate on possible etiologies. Certainly, each program director must ensure an adequate operative experience for their trainees, particularly if both paradigms are present in the same institution. Although some of this difference may be attributed to case-mix distribution over time, this does not exactly explain the discrepancy in all categories. In addition, the senior resident data are diluted by junior resident case numbers and therefore extrapolation based on these must be done cautiously. All in all, these data are hypothesis-generating and suggest that, as a specialty, vascular surgeons must further investigate these training paradigms to ensure minimal discrepancies and adequate and equitable training for all.

Overall, our findings, at a minimum, represent a need to protect autonomy during surgical training. IVSRs have 2 fewer years of total surgical training and operating room exposure before becoming board-certified vascular surgeons. Furthermore, programs looking to expand case volume may have to introduce offsite experiences as a means of ensuring adequate case volume. As challenges, such as duty hour restrictions and changing technology in treatment, continue to influence the training of young vascular surgeons, we, as surgical educators, must continuously monitor trends within the training paradigms. As these challenges surface, we must make appropriate adjustments to our training programs to meet the evolving needs.

In conclusion, the final years of vascular surgery training offer an increased opportunity for autonomy-driven experience in the treatment of peripheral arterial occlusive disease. Although both training paradigms offer operative experiences that meet criteria for graduation, it seems that VSFs currently perform more endovascular and open cases than their IVSR counterparts for peripheral arterial occlusive disease during the final phase of training. These findings may be contradictory to current thinking regarding the vascular surgery training paradigms.

Conflict of interest

The authors have no conflicts of interest to disclose.

Funding

The authors did not receive any funding support.

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