Impact of New Vascular Fellowship Programs on Vascular Surgery Operative Volume of Residents in Associated General Surgery Programs

Alexander H Shannon, MD, William P Robinson III, MD, FACS, John B Hanks, MD, FACS, John R Potts III, MD, FACS

BACKGROUND: General surgery (GS) resident vascular surgery (VS) operations have declined significantly in the last 15 years. We hypothesized that initiation of VS fellowship programs (VSFPs) contributes to that decline. This study examined the effect of establishing new VSFPs on VS case volumes of residents in associated GS programs.

STUDY DESIGN: General surgery programs were reviewed if associated with VSFPs accredited since July 1, 2002 that had 1 or more matriculants (GS case logs only available since 2002 to 2003). Total VS cases by residents in those programs was analyzed before and after matriculation of first fellow into the associated VSFP.

RESULTS: Twenty-two programs were available for analysis. General surgery case-log data were available variably from 0 to 14 years before and 0 to 14 years after first fellows in the associated VSFPs. In 12 programs with 4 years of data before and after matriculation of associated VSFPs' first fellows, VS cases increased from 109.6 ± 32.4 cases to 143.65 ± 78.15 cases in 4 years before matriculation ($p = 0.008$) of VS fellows and then declined from 143.65 to 114.04 ± 46.97 in 4 years after ($p = 0.0134$). In all 16 programs with 4 years of data after matriculation of the associated VSFP's first fellow, VS cases declined from 123.37 ± 71.42 to 103.23 ± 44.35 ($p = 0.0232$).

CONCLUSIONS: New VSFPs diminished peak VS operative volume of residents in associated GS programs, thereby contributing to declining national average number of VS cases done by GS residents. Nevertheless, resident VS case volumes remained robust in most GS programs associated with new VSFPs. Additional study is required to determine both resident perception and overall impact of VSFPs on associated GS training. (J Am Coll Surg 2019;228:525–535.

The volume of vascular surgery (VS) cases performed by general surgery residents (GSRs) has declined substantially.[1-3] A recent review of case logs from the last 15 years demonstrated an approximate 38% decrease in number of open arterial operations reported by GSRs.[1] This dramatic decline in the volume of open vascular cases, including open aortic aneurysm, carotid endarterectomy, and lower extremity bypass, for trainees in both GS and VS has been well documented.[3-7]

The reason for the decline in GSR vascular case volume is unclear and, to date, there has been a paucity of evidence to fully explain this trend. Multiple factors might be responsible, including the dramatic shift to endovascular therapy, the impact of VS independent programs ("5+2 fellowship"), development and proliferation of integrated VS residency ("5-0") programs, as well as the increased number of GSRs in training programs. According to the ACGME, as of 2017, there were 90 accredited VS fellowship programs (VSFP) with 114 trainees total in the US.[8] During the last

Disclosure Information: Dr Potts is a full-time employee of the ACGME. He has no voice or vote in accreditation decisions made by the ACGME Review Committee for Surgery. All other authors have nothing to disclose.

Presented at the Southern Surgical Association 130th Annual Meeting, Palm Beach, FL, December 2018.

Received December 20, 2018; Accepted December 20, 2018.

From the Department of Surgery (Shannon, Hanks), Division of Vascular and Endovascular Surgery (Robinson), University of Virginia, Charlottesville, VA, and Accreditation Council for Graduate Medical Education, Chicago, IL (Potts).

Correspondence address: William P Robinson III, MD, Division of Vascular and Endovascular Surgery, University of Virginia Medical Center, PO Box 800700, Charlottesville, VA 22903. email: wr4w@virginia.edu

https://doi.org/10.1016/j.jamcollsurg.2018.12.010
ISSN 1072-7515/18

Abbreviations and Acronyms
AY = academic year
GSR = general surgery resident
VS = vascular surgery
VSFP = vascular surgery fellowship program

2 decades, the number of GSRs has increased, which has heightened concerns for adequate VS exposure during GS residency.[1]

The impact of an associated fellowship on resident operative volume has been the subject of much debate and has been identified as an important contributor to the decrease in GSR volume of nonvascular cases.[9-11] The purpose of this study was to examine the effect of new VSFPs on VS operative volume of GSRs in associated GS residency programs. We hypothesize that presence of a VSFP contributes to a decline in VS case volume among GSR in the associated training program.

METHODS

In compliance with the Declaration of Helsinki, this study is exempt from review by the IRB due to the de-identified nature of the data, precluding the possibility of obtaining informed consent. General surgery programs that were associated with a VS independent programs (5+2 fellowship) receiving initial accreditation from the ACGME between July 1, 2002 and June 30, 2017 were identified. The choice of July 1, 2002 as the boundary for inclusion was mandated by the fact that individual GSR cases logs available for review extended only as far back as the 2002 to 2003 academic year (AY). General surgery residency programs were included for review if they were located in the same ACGME sponsoring institution as one of the new VSFPs and at least 1 fellow had matriculated into the associated VS program. For those GS programs that were included, the total number of VS cases reported by each resident as reflected on the "Defined Categories Report" (2002 to 2003 through 2011 to 2012) or "Minimums Report" (2012 to 2013 through 2016 to 2017) was recorded. In doing so, the number of residents completing each program in each year was also noted. Also recorded was the year of matriculation of the first fellow into the VS program associated with the GS program. The number of vascular cases reported by residents was then analyzed for trends based on the number of years before or after matriculation of the first fellow into the associated VS program. Statistical analyses were performed using Excel Analysis ToolPak included regression (means), analysis of variance, and Student's *t*-test. Data are presented as mean ± SD.

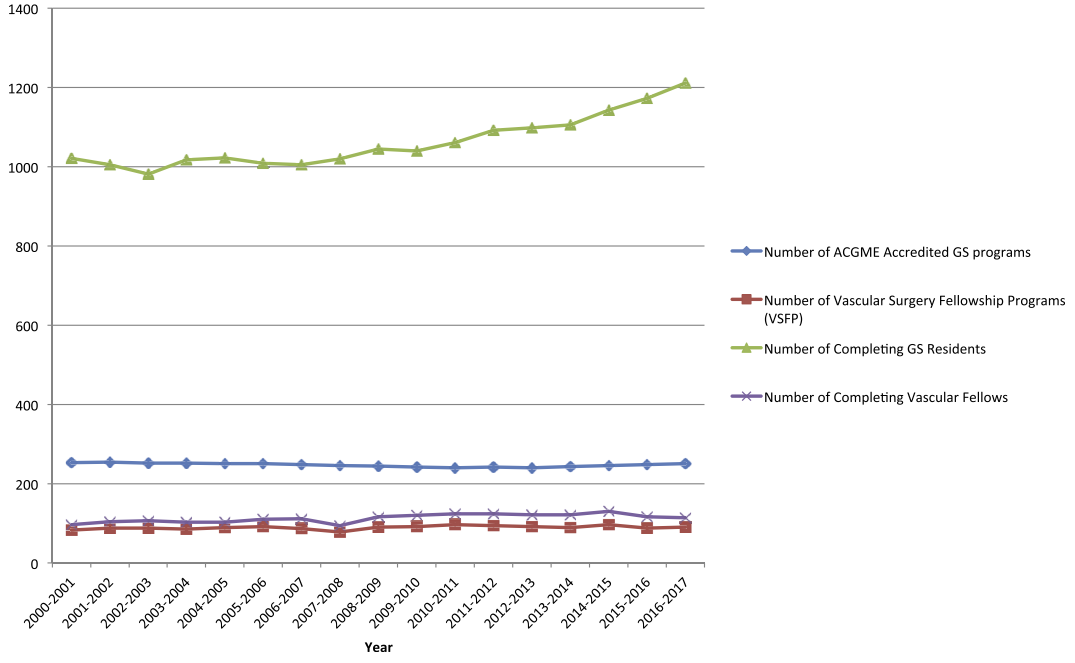

Figure 1. National trends in number of ACGME-accredited general surgery (GS) and vascular surgery fellowship programs and completing GS residents and vascular surgery fellows.

RESULTS

Vascular surgery fellowship programs and general surgery program baseline

Demographics

The number of ACGME-accredited GS programs has remained stable during the analysis period (AY 2002 to 2003: 252 programs, AY 2016 to 2017: 251 programs); however, the number of graduating GSRs has increased by nearly 200, from 1,021 in AY 2002 to 2003 to 1,211 in AY 2016 to 2017 (Fig. 1). The number of vascular fellows completing fellowship training has increased from 106 to 114 per year during this same time period.

Thirty VS independent (fellowship) programs received initial accreditation from the ACGME between July 1, 2002 and June 30, 2017. One program was excluded because there is no GS program in its ACGME sponsoring institution. Another program was excluded because its initial accreditation was conferred almost immediately after withdrawal of accreditation of the previous long-standing VS program in the same institution. One program was excluded because it voluntarily withdrew shortly after achieving initial accreditation. Five programs were excluded because no fellow had completed the program as of June 30, 2017. Resident case logs in 22 GS programs associated with new VSFPs were available for review (Fig. 2).

The first VS fellows entered the newly accredited VSFP at various times between AY 2002 to 2003 and AY 2016 to 2017, resulting in a range of available GS program case logs from 0 to 14 years before the first VS fellow at each program, and 0 to 14 years after the first VS fellow (Fig. 3). Of the 22 programs included in our analysis, 10 had fewer than 4 years of operative data before or after the training of the first VS fellow, leaving 12 GS programs for a subgroup analysis with comparable numbers of years of case logs available before and after the matriculation of the VS fellow.

Vascular surgery cases performed by general surgery residents

In the 22 identified GS programs with new VSFPs from 2002 to 2017, the number of VS cases performed by

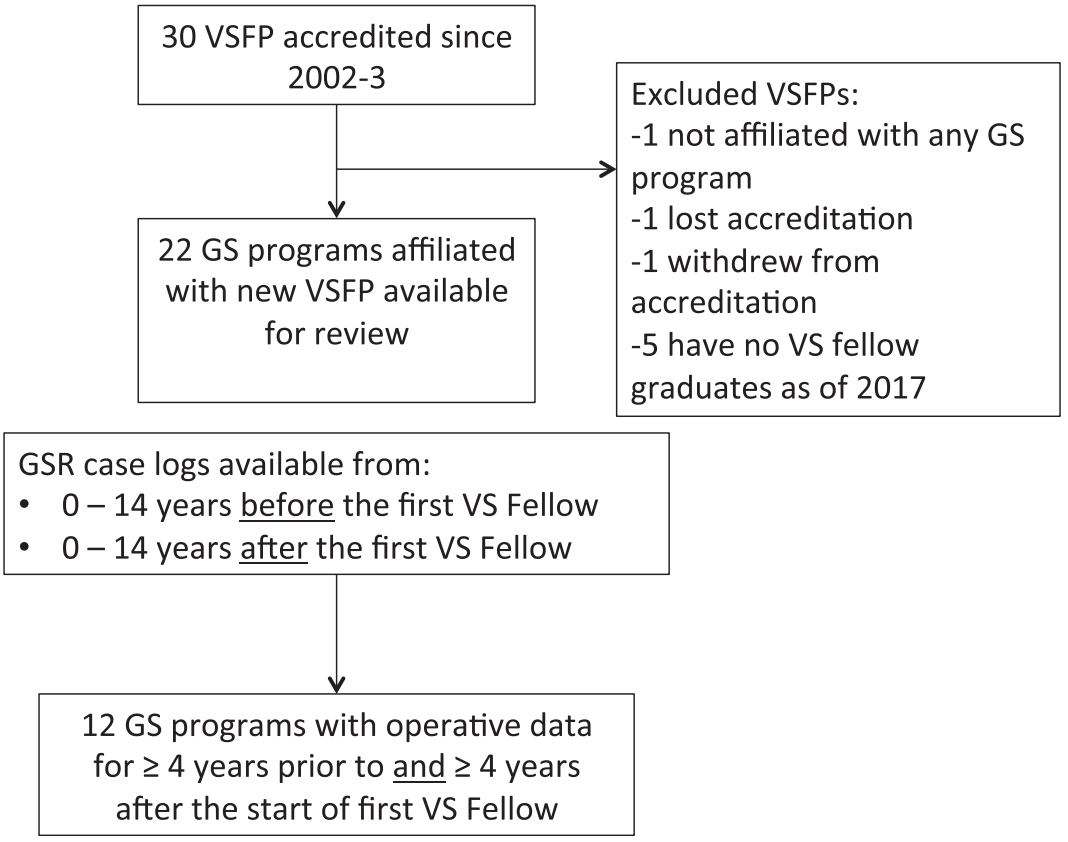

Figure 2. Overview of general surgery (GS) programs with vascular surgery fellowship programs (VSFPs) accredited since 2002 to 2003 included for analysis. GSR, general surgery resident; VS, vascular surgery.

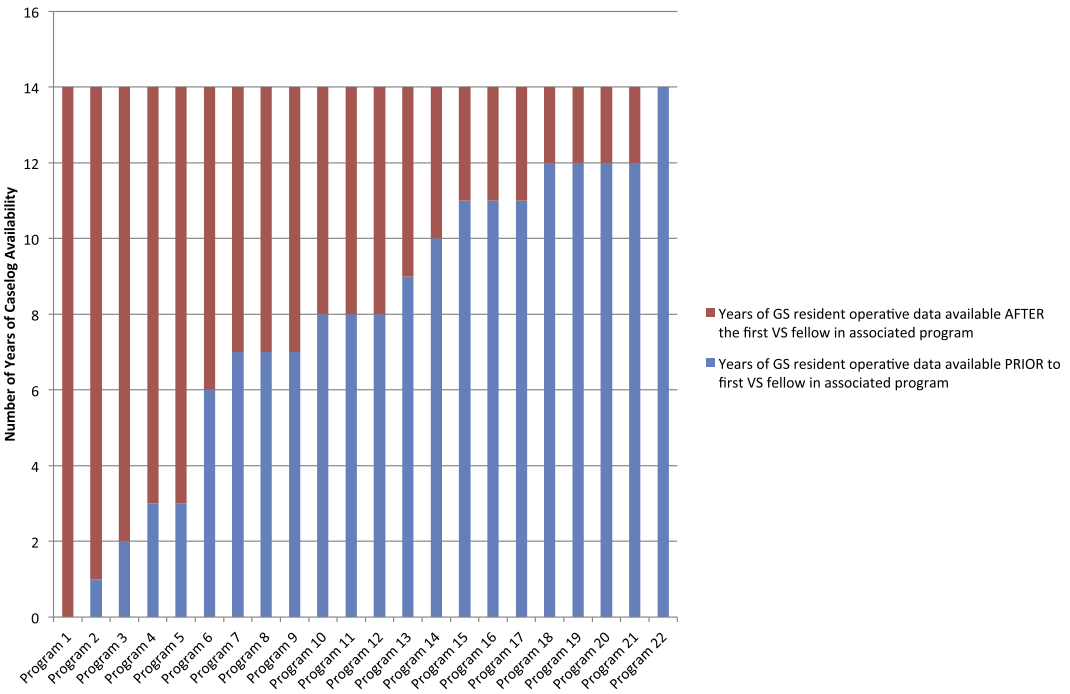

Figure 3. Years of general surgery (GS) resident case-log available among 22 programs from academic year 2002 to 2003 through academic year 2016 to 2017. VS, vascular surgery.

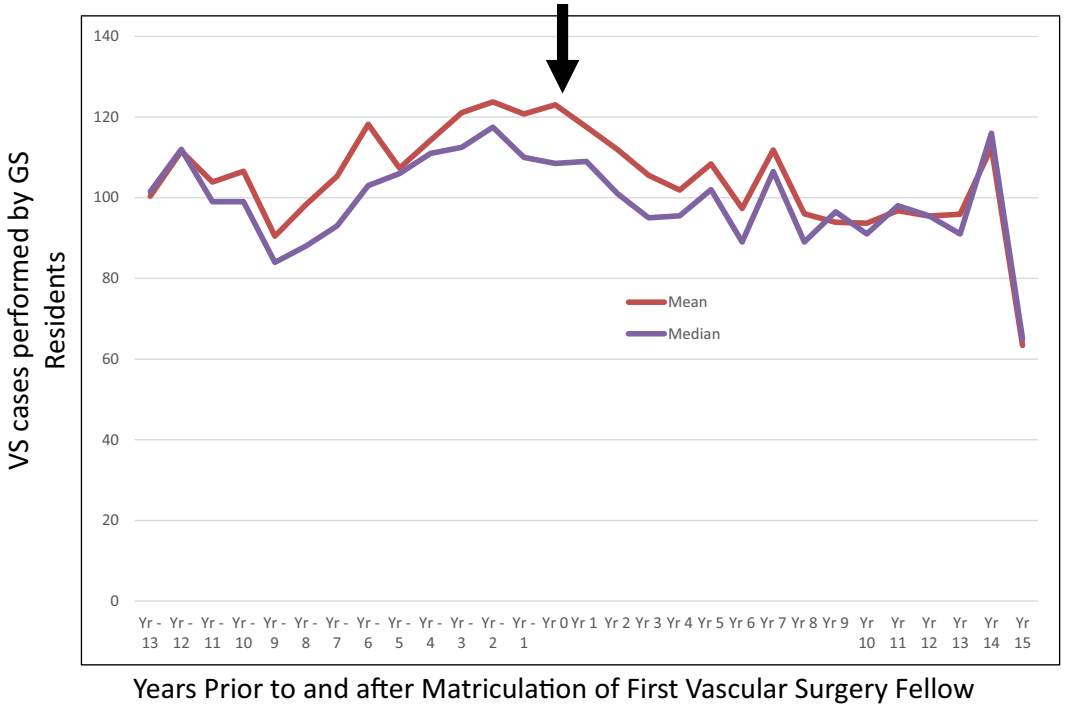

Figure 4. Available vascular surgery (VS) case log data from all 22 general surgery (GS) programs at all intervals. Arrow marks the year of matriculation of the first VS fellow. Yr, year.

GSRs in these programs increased from a mean 100.4 ± 14.59 cases 13 years before the initiation of the VSFP to a mean of 123.05 ± 63.73 cases during the first year of VSF matriculation. In the 13 years post-VSF matriculation, the mean number of VS cases decreased to 95.9 ± 50.62 cases (Fig. 4).

Subgroup analysis of the 12 programs with at least 4 years of data before and after VSF matriculation demonstrated that number of vascular cases performed by GSRs increased from a mean of 109.6 cases 4 years before the VSFP initiation to a mean of 143.65 cases during the first year a VSF was present in the program. General surgery resident vascular case volume fell to a mean of 114.03 cases in the 4 years after the first fellow was introduced ($p = 0.0134$; Fig. 5). Importantly, the mean number of cases in year 4 before the first fellow matriculating (109.6 cases) was slightly less than the mean of 114.03 cases seen at year 4 after the first fellow.

Fourteen of the programs reviewed have been associated with a VSFP for a minimum of 5 years (Fig. 6). Of those, 9 were higher than the 2016 to 2017 national average of 108.1 vascular cases. All 14 programs were higher than the 44 vascular case minimum established by the ACGME Review Committee for Surgery.

DISCUSSION

This analysis demonstrated that a new VSFP was associated with a substantial decrease in the peak VS operative volume for GSRs in associated programs, which supports our hypothesis that VSFPs have contributed to the current decline in GSR vascular case volume. Nevertheless, GSR VS case volumes remained robust in many GS programs associated with new VSFPs. Fellowships were initiated in institutions with increasing VS case volume as indicated by the increasing number of vascular cases performed by GSRs in the years before fellow matriculation. Overall, the total number of vascular cases performed by GSRs in the programs reviewed remains higher than the Review Committee for Surgery-defined category minimum numbers for GSRs.[12]

Our data reinforce the findings of previous studies. In their retrospective review of ACGME surgical case logs, Hanks and colleagues[9] demonstrated that GSRs in programs without vascular fellows performed significantly more peripheral obstructive, cerebrovascular, and endovascular cases than those in programs affiliated with a vascular fellowship. It should be noted, however, that the study by Hanks and colleagues was limited to a single year of data (2009). Apart from that analysis, earlier study of VS fellowships and

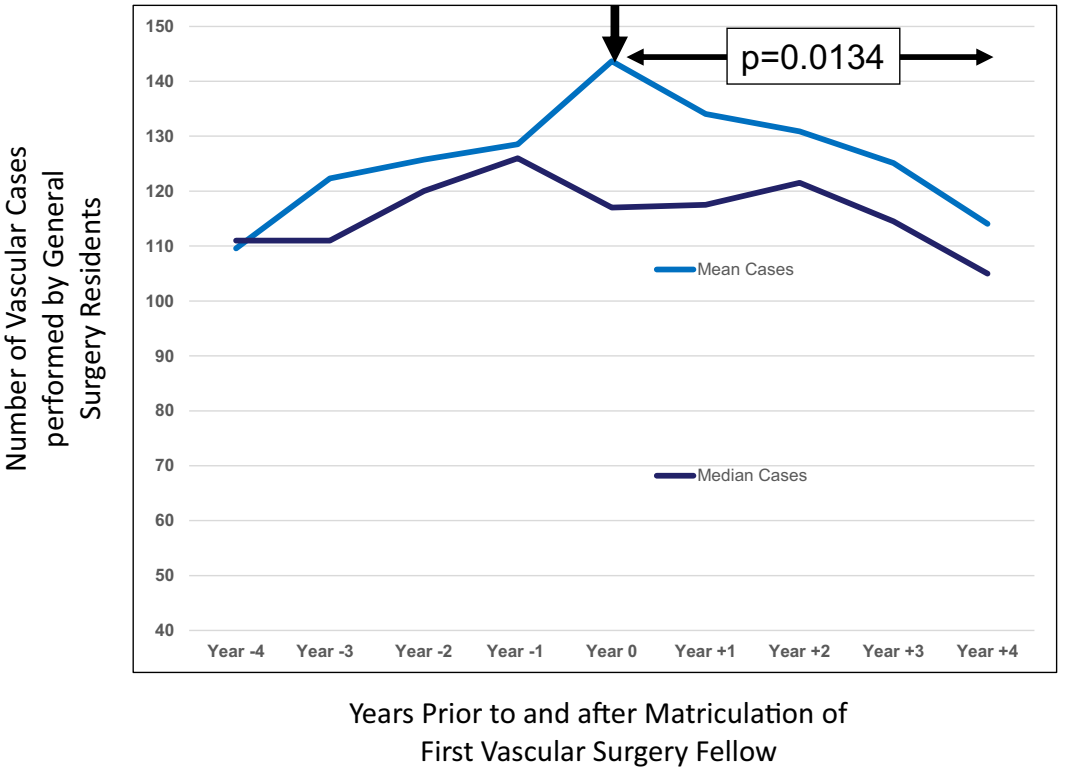

Figure 5. All programs with data 4 years before through 4 years after matriculation of the first vascular surgery fellow (n = 12). Arrow marks the year of the matriculation of the first vascular surgery fellow.

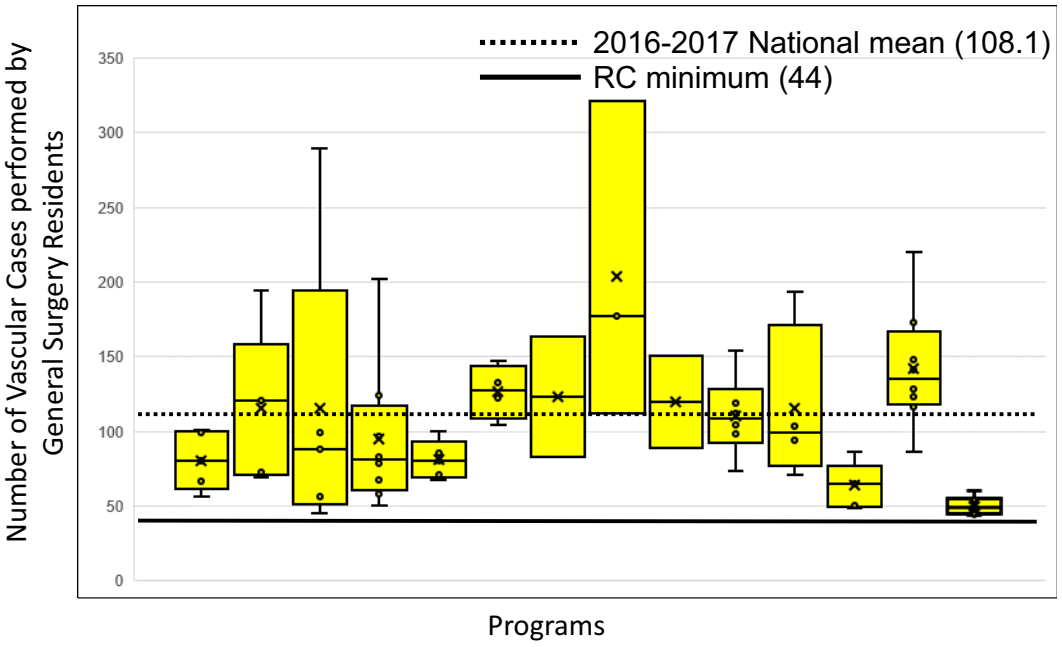

Figure 6. The 2016 to 2017 vascular surgery cases in general surgery programs associated with vascular surgery fellowship program ≥5 years. RC, ACGME Review Committee.

subsequent impact on GSR vascular case load has generally shown a negative impact, though much of the earlier literature has been limited by single-center analysis.[3-5] In one study, Grabo and colleagues[13] evaluated national GSR case log data from 1996 to 2006 and demonstrated that GSR vascular case load decreased by 34% during this 10-year time period, and vascular fellow case volume increased by 78%, due mainly to an increase in the performance of endovascular procedures. This reveals a related, although distinct trend of decreasing exposure to open VS procedures among GSRs, including open aortic, cerebrovascular, and lower extremity cases.[5,13] Recent studies suggest that the widespread shift in vascular treatment from open to endovascular procedures is responsible for the decreasing open vascular surgical volume for GSRs.[14,15]

Current literature presents conflicting evidence evaluating the impact of subspecialty fellowships on GSR case volume in fields other than VS.[10] Hanks and colleagues[9] concluded that the overall impact of fellowships in colorectal, vascular, minimally invasive, and endocrine surgery on GSR caseload is minimal. Zyromski and colleagues[16] demonstrated that hepatopancreatobiliary fellowship can be incorporated into high-volume clinical training programs without detracting from GSR's experience. Similarly, a review of resident case logs showed GSRs did not experience reductions in the total number of laparoscopic cases with the addition of an advanced laparoscopic fellowship.[17] However, these were single-center studies, which limits the generalizability of these findings. When looking at national data, the impact of fellowships on resident case volume appears mixed or negative, especially in urologic surgery, pediatric surgery, minimally invasive surgery, and gynecologic surgery.[13,18-22]

Although our data tend to concur with trends in other surgical subspecialties, the presence of an affiliated VSFP did not result in lower than national average case numbers for the majority of GS programs in this analysis, and no resident in the study programs had less than the ACGME-defined minimum number of vascular cases. It is important to note that VSFPs were initiated in institutions with increasing VS case volume as indicated by the increasing number of vascular cases performed by GSRs. Maintaining vascular case volume for GSRs will be best served by initiating VSFPs in programs with robust vascular volume.

The clinical impact of the change in the number of VS operations performed by GSRs is difficult to determine, especially as modern training shifts from quantity- to proficiency-based metrics. It is essential to continue to ensure adequate open vascular surgical opportunities for GS trainees. The fundamentals of open VS, including dissection, control, and suturing of blood vessels, are essential skills in the training of every GSR and can be applied in a myriad of different subspecialties. Ensuring adequate open vascular case volume for GSRs is of particular importance, as endovascular procedures are replacing

the once predominant open vascular cases, such as aortic aneurysm repairs and lower extremity bypasses.[6,14,23]

As surgical techniques and the field of VS evolve, so too will the need to continue to hone the VS training experience for GSRs to ensure adequate open vascular exposure to acquire the operative skills mentioned. There has been a dramatic shift from open operation to endovascular therapy,[4,6] which has limited the training opportunities for GSRs, VSFs, and integrated vascular residents in some programs. There are simply fewer traditional open cases to go around. Additional strategies should be considered to maintain the GSR experience in VS. Many "hybrid" aortic and lower extremity procedures combine open exposures of major blood vessels with endovascular therapy remote from that site. These open exposures are important training opportunities for GSRs. Program directors should continue to rotate both junior- and senior-level residents on vascular services and closely monitor the number and types of vascular cases their residents are performing. Establishing rotations with vascular or general surgeons who are not affiliated with vascular fellowship, might be another avenue to maintain vascular case volume. Additionally, strategies such as simulation training will need to be used to help programs and trainees get the maximal educational benefit from the remaining open operations. Regardless of the strategy used, ensuring appropriate open vascular case volume to develop foundational vascular operative skills will be essential in the training of GSRs, especially as the field shifts toward minimally invasive approaches. To maintain GSR vascular case numbers, program directors need to be aware of the impact of vascular fellows on GS trainee's vascular experience.

Moving forward, it will be important to understand GSR perceptions of the impact of a new VSFP on their experience in VS. There are few studies that depict the qualitative GSR experience in programs with affiliated fellowships. In one retrospective review of surgical residencies in Australia and New Zealand, Petrushnko and colleagues[24] found that although fellows can add to the educational aspect of training, residents noted a subjectively lower quality of operative experience. Conversely, assessment of OB/GYN residents in programs with and without gynecologic oncology fellowships showed that fellowship presence increased resident perception of exposure to complex cases.[25]

Limitations of this study include its retrospective observational nature and inability to control for unmeasured variables. The ACGME case logs are self-reported by trainees and subject to reporting error, particularly among procedural classification. Our analysis was limited to case volume, but other effects of VSFP presence on associated GS programs warrant additional analysis, including the level of resident satisfaction with VS training, and resident performance on board examinations. Additionally, our study assessed total number of vascular cases only and did not evaluate the distribution of types of cases performed by residents. Finally, it must be emphasized that the effect of VSFPs on associated GS programs cannot necessarily be generalized to other types of fellowship programs.

CONCLUSIONS

Vascular fellowships are an integral aspect of continuing to produce qualified vascular surgeons in an effort to meet the increasing demand within the field.[26] However, VSFPs are associated with a decline in the number of vascular cases performed by residents in associated GS programs. Program directors and surgical department chairs must be cognizant of the impact of VSFPs on the training experience of GSRs, particularly given the dramatic shift of VS from open operations to endovascular intervention. Multifaceted strategies to ensure GSRs get adequate vascular exposure to develop fundamental skills should be used and evaluated.

Author Contributions

Study conception and design: Shannon, Robinson, Hanks, Potts

Acquisition of data: Potts

Analysis and interpretation of data: Shannon, Robinson, Hanks, Potts

Drafting of manuscript: Shannon, Robinson, Hanks, Potts

Critical revision: Shannon, Robinson, Hanks, Potts

REFERENCES

1. Potts JR 3rd, Valentine RJ. Declining resident experience in open vascular operations threatens the status of vascular surgery as an essential content area of general surgery training. Ann Surg 2018;268:665–673.
2. Malangoni MA, Biester TW, Jones AT, et al. Operative experience of surgery residents: trends and challenges. J Surg Educ 2013;70:783–788.
3. Tanious A, Wooster M, Jung A, et al. Open abdominal surgical training differences experienced by integrated vascular and general surgery residents. J Vasc Surg 2017;66:1280–1284.
4. Sternbergh WC 3rd, York JW, Conners MS 3rd, Money SR. Trends in aortic aneurysm surgical training for general and vascular surgery residents in the era of endovascular abdominal aortic aneurysm repair. J Vasc Surg 2002;36:685–689.
5. Joels CS, Langan EM 3rd, Cull DL, et al. Effects of increased vascular surgical specialization on general surgery trainees, practicing surgeons, and the provision of vascular surgical care. J Am Coll Surg 2009;208:692–697; discussion reply 697–699.
6. Suckow BD, Goodney PP, Columbo JA, et al. National trends in open surgical, endovascular, and branched-fenestrated

endovascular aortic aneurysm repair in Medicare patients. J Vasc Surg 2018;67:1690–1697.
7. Krafcik BM, Sachs TE, Farber A, et al. Assessment of open operative vascular surgical experience among general surgery residents. J Vasc Surg 2016;63:1110–1115.
8. Vascular Surgery Case Logs: National Data Report. Available at: 2017. https://www.acgme.org/Data-Collection-Systems/Case-Logs-Statistical-Reports. Accessed October 18, 2018.
9. Hanks JB, Ashley SW, Mahvi DM, et al. Feast or famine? The variable impact of coexisting fellowships on general surgery resident operative volumes. Ann Surg 2011;254:476–483; discussion 483–485.
10. Plerhoples TA, Greco RS, Krummel TM, Melcher ML. Symbiotic or parasitic? A review of the literature on the impact of fellowships on surgical residents. Ann Surg 2012;256:904–908.
11. Potts JR 3rd. Shifting sands of surgical education. J Am Coll Surg 2018;227:151–162.
12. Case Log Information: Surgery Minimums. Available at: 2018. https://www.acgme.org/Specialties/Case-Log-Information/pfcatid/24/Surgery. Accessed October 16, 2018.
13. Grabo DJ, DiMuzio PJ, Kairys JC, et al. Have endovascular procedures negatively impacted general surgery training? Ann Surg 2007;246:472–477; discussion 477–480.
14. Lin PH, Bush RL, Milas M, et al. Impact of an endovascular program on the operative experience of abdominal aortic aneurysm in vascular fellowship and general surgery residency. Am J Surg 2003;186:189–193.
15. Arko FR, Lee WA, Hill BB, et al. Impact of endovascular repair on open aortic aneurysm surgical training. J Vasc Surg 2001;34:885–891.
16. Zyromski NJ, Torbeck L, Canal DF, et al. Incorporating an HPB fellowship does not diminish surgical residents' HPB experience in a high-volume training centre. HPB (Oxford) 2010;12:123–128.
17. Kothari SN, Cogbill TH, O'Heron CT, Mathiason MA. Advanced laparoscopic fellowship and general surgery residency can coexist without detracting from surgical resident operative experience. J Surg Educ 2008;65:393–396.
18. Duffy JW 3rd, Thomas JC, Makari JH, et al. The impact of a fellowship on resident training in an academic pediatric urology practice. J Urol 2008;179:720–723; discussion 723.
19. Potts JR 3rd. Establishment of a New Pediatric Surgery Fellowship Program Results in a Significant Reduction of Pediatric Surgery Cases Performed by Residents in the Associated General Surgery Program. Presented at the 2018 Annual Meeting of the Western Surgical Association November 6, 2018.
20. Marks JM, Nussbaum MS, Pritts TA, Scheeres DE. Evaluation of endoscopic and laparoscopic training practices in surgical residency programs. Surg Endosc 2001;15:1011–1015.
21. Rattner DW, Apelgren KN, Eubanks WS. The need for training opportunities in advanced laparoscopic surgery. Surg Endosc 2001;15:1066–1070.
22. Metheny WP, Sherline DM. The resident and fellow relationship in obstetrics and gynecology. Am J Obstet Gynecol 1988;158:618–624.
23. Nandivada P, Lagisetty KH, Giles K, et al. The impact of endovascular procedures on fellowship training in lower extremity revascularization. J Vasc Surg 2012;55:1814–1820.
24. Petrushnko W, Perry W, Fraser-Kirk G, et al. The impact of fellowships on surgical resident training in a multispecialty cohort in Australia and New Zealand. Surgery 2015;158:1468–1474.
25. Cohn DE, Roney JD, O'Malley DM, Valmadre S. Residents' perspectives on surgical training and the resident-fellow relationship: comparing residency programs with and without gynecological oncology fellowships. Int J Gynecol Cancer 2008;18:199–204.
26. Williams K, Schneider B, Lajos P, et al. Supply and demand: will we have enough vascular surgeons by 2030? Vascular 2016;24:414–420.

Discussion

DR GILBERT R UPCHURCH (Gainesville, FL): In this work from the University of Virginia and the Accreditation Council for Graduate Medical Education (ACGME), Dr Robinson and coauthors have examined the ACGME case logs of general surgery residents from 2002 to 2017 in order to determine if the presence of a new vascular fellowship affected the number of vascular surgery cases being performed by general surgery residents. As part of their methodology, they selected the 4 years before as the "ramp up" phase, and then compared that with 4 years afterward to determine if there were differences in the number of cases. Not surprisingly, the number of vascular cases performed by general surgery residents decreased by about 20%; however, the case numbers remained well above the minimum numbers of 44, averaging about 100 cases per general surgery trainee per year.

It seems as though during the same period, the overall number of general surgery residents went up by almost 20% even though the number of general surgery resident programs remained flat. What role might the increase in general surgery residents have on decreasing the number of vascular cases performed by general surgery residents? Second, you touched on this a little bit, but it is well documented that we are heading for a fairly significant crisis in terms of not having enough vascular surgeons in the US, given the explosion of diabetes and obesity, and with people living longer. The vascular community, in collaboration with the American Board of Surgery and the Vascular Surgery Board, approved a primary certificate in vascular surgery. During the same period of your study, there were many more new vascular residencies opened up than there were fellowships. What might the impact of these vascular surgery residents be on the general surgery case logs? This might be even more important given the fact that many of these cases, such as amputations, veins, and traumas, are going to be managed by the postgraduate year 1 and 2 surgeons in their general surgery years.

Finally, during the same period, there has really been a complete transition of vascular surgery to endovascular as opposed to open surgery, such that the number of open aortic aneurysms performed by a finishing vascular surgery fellow in the year 2018 is only about 5. How can one justify sharing those cases with general surgery residents in this particular setting?

I think your point is that we have to come up with new paradigms to get our general surgery residents more vascular surgery exposure. At our Veteran Affairs Hospital at the