Current challenges to vascular trauma training across levels and regions

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Surgical training and competency have survived multiple iterations of change, adjustments and rebirths owing to shifts over the last three decades in training hours, operative volume, access, funding, health care delivery, simulation, and a global pandemic. Demonstrating competency in high-risk clinical scenarios is critical to favorably impact overall morbidity and mortality for acute surgical pathologies, including vascular trauma. There has been a significant paradigm shift in general and vascular surgery training that challenges our ability to effectively achieve these aims. The specific challenges of teaching and acquiring competent surgical techniques for vascular trauma also possess unique obstacles that have been evolving for decades. One obvious challenge is the shortened training hours for all trainees whether general surgery residents (GSRs), vascular fellows, or integrated vascular residents. Operative trauma seems to have been affected in a disproportionate way compared with other core GS sections. Based on review of operative Accreditation Council for Graduate Medical Education logs in 2010, after implementation of the 80-hour work week program requirement (2003), operative volumes in 13 core GS categories remained unchanged, however 4 of 19 categories showed decreases, including operative trauma which was significantly decreased (26.2 vs 13.5 cases; $P < .05$).[1] Similarly for total vascular volume, GSRs showed an asymmetric impact of changes in vascular surgery volume types as open operative volume continues to fall nationally. Over a 10-year review of the Residency Review Committee for Surgery data, GS vascular case volumes decreased by 34%, mirroring a 58% decrease in elective open aortic aneurysm repair, while total vascular fellow case volumes have increased by 78%, owing largely to expansion in endovascular case volumes ($P < .0001$). The open vascular experience for GS residents has not followed the volume increases that we have seen in vascular surgery fellow and resident training.[2]

GS residency, vascular surgery residency, and vascular fellowship Accreditation Council for Graduate Medical Education case logs were reviewed between 2000 and 2017 to look at 5-year consecutive cases, including over 19,031 GS residents, 603 vascular fellows, and 129 integrated vascular residents. Vascular fellows and vascular residents performed significantly more vascular trauma (14.0 vascular fellows vs 15.8 integrated vascular residents vs 2.3 GSRs; $P < .01$) than their GSR counterparts. GS arterial volume decreased from 73.7 to 39.5 during the study period.[3,4] With the influx of different treating specialists, the decrease in overall trauma operative volumes and the hours restrictions affecting physical time in the hospital, there has been a negative impact on surgical competency for these case volumes, more so than on other core categories. These cases often occur outside of elective surgical service hours, which poses a challenge that seems not to similarly affect elective surgical case volumes.

This circumstance has not been limited to training programs in the United States. However, the burden is inconsistent. In Europe, major vascular injuries only occur in 1% to 2% of trauma secondary to lower numbers of penetrating injuries.[5] Whereas, US data shows that peripheral or central vascular injury accounts for ≤20% of all trauma-related deaths.[6] There has been a shift in who is caring for vascular trauma patients and in their management. In a study conducted in 2009, there was a 2.5-fold increase in endovascular treatment of vascular injuries compared with the preceding decade with interventional radiologists involved in 25% of injuries.[7] The PROOVIT registry shows that, of 3249 arterial traumas from 2013 to 2019, 42% were nonoperative, 44% were open, and 14% were endovascular treatments. The use of endovascular techniques for junctional injuries increased by 5% per year throughout the study period and was used more commonly for thoracic, abdominal, and cerebrovascular injuries with higher injury severity scores. Endovascular repair resulted in significantly lower mortality than open repair across these categories with thoracic (5% endovascular vs 46% open; $P < .001$) and abdominal (15% endovascular vs 38% open; $P < .001$).

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Overall endovascular treatment increased by 10% over the 6-year study period.[8]

Trauma center centralization and changes to rural surgical access also have affected trainee involvement and exposure to specialized vascular surgical care and techniques. Contrary to traditional academic surgical dictum, trauma centers of similar level designation are not all made equal. During a review of penetrating volume from 2021, across >700 trauma centers nationally involving 822,571 patients, 49% of all level 1 trauma centers had a laparotomy volume that were considered as high-volume centers (>25 cases per year), 27% in moderate volume (13-24 cases/year), and 24% in low volume (<12 cases/year) for penetrating trauma. More than one-half of level 1 centers had basic laparotomy volumes in the moderate or low volume categories despite the identical center designation.[9]

To extrapolate this trend to vascular trauma, Yan et al[10] provided a matched comparison between two urban, academic-affiliated level 1 trauma centers between 2004 and 2014. There was a significant difference amongst the graduating residents experience with vascular trauma per resident career of 12 vascular trauma cases in the higher volume program compared with 5 in the lower volume program ($P < .001$), with repair of peripheral vessels constituting a bulk of reported volume.[10]

Because access to high-volume trauma care is more variable then might be assumed by designation status, the effects of rural community programs are also facing dynamic challenges to training. Based on workforce data that exhibited stable workforce numbers back to 1975, the Balanced Budget Act of 1997 instituted a federal cap on graduate medical education positions nationally that has halted residency expansions. Program numbers show that as many as 150 hospitals could readily accommodate new GS residency programs, and in that same period >170 rural hospitals have closed owing to low patient occupancy rates and limited financial resources.[11]

Beyond the definitive impact of limited access to care on these patient communities, these changes to rural health care also then require academic affiliations with larger urban centers to provide trauma training, contributing to increases in other learners and experience with complex vascular trauma. Even urban academic centers have maintained training affiliations with larger centers traditionally. One example, the John H. Stroger Cook County Hospital in Chicago, has provided training to Rush University, Northwestern University, Midwestern University, and, up until May 2018, the University of Chicago. Cook County Hospital Trauma Center trains >100 residents per year from 5 affiliated hospital systems.[12]

As we see changes in volume, types of technical repair, collaborative teams, and general and rural access to high-acuity operative trauma, we also face challenges with autonomy affecting surgical competency at all levels of training. A survey in 2020 by Quinn et al[13] showed that 85% of graduating surgical residents chose a subspecialty fellowship with confidence level in autonomous practice being a driving force to avoid a direct to practice path. A recent review, reiterated this concern of substandard training and their obstacles divided into four subcategories: education in the shadow of treatment, inefficient education, patient safety vs trusting residents for independent practice, and unstructured assessment.[14] These impacts remain critical on competent practice because GSRs are entering trauma and vascular fellowships with different experience levels than in prior decades of training. It is evident then that there are differences in perceived confidence after training between trauma and vascular surgeons. A survey of members of American Association for the Surgery of Trauma and Vascular and Endovascular Surgery Society/Western Vascular Society of 247 US surgeons showed that vascular surgeons had greater experience and comfort with managing vascular trauma with trauma surgeons reporting inability to maintain skillset (27%) and unfamiliarity with techniques (32%) as the most common barriers to treating vascular trauma at their institution. Of the two cohorts both treated vascular trauma (vascular, 79.8%; trauma, 82.2%); however, 58.9% of trauma surgeons surveyed stated they performed vascular repairs less than once a month, compared with >70% of vascular surgeons who performed vascular trauma repairs at least once a month. Of the total cohort, 98.8% of vascular surgeons and 84.0% of trauma surgeons felt vascular surgeons were suited to manage vascular injuries at certain locations ($P < .001$).[15] A 2013 review of 27,224 trauma patients at a single institution showed that vascular surgeons were called by trauma surgeons to repair injuries with higher Mangled Extremity Severity Scores, arrived more often by transfer, upper extremities with higher Injury Severity Scores, and lower extremity injuries with higher Mangled Extremity Severity Scores. This study showed no differences in patency or amputation rates for the repairs performed, although there was lack of long-term surveillance data after discharge.[16]

Logically, then, program mindset has shifted to roles of simulation to make up for smaller volumes of operative experience, as one reliable means to increase competency. Vascular surgery simulators were compared validating 34 vascular surgery simulators and training courses for both open and endovascular training by Haiser et al[17]; however, only 7 studies out of 76 eligible studies achieved a Level of Effectiveness Score of 3 out of 5. Level of Effectiveness Scores were defined as (1) trainee satisfaction; (2) change in performance; (3) behavioral change in clinical context; (4) direct changes to patient care outcomes; and (5) changes on systemic level. Such results suggested only 10.8% of simulators reviewed

suggested any type of downstream long-term behavioral changes in a patient care context.[17]

A review by Tullos and Sheahan[18] in 2022 reiterated the importance of high-quality vascular simulation in vascular surgery, with efficacy affected by expert level of proctor and high-fidelity simulators as the most crucial factors for open surgery, with further support for endovascular simulation benefits. Dedicated trauma exposure and control courses such as Advanced Trauma Operative Management (ATOM), Advanced Surgical Skills for Exposure in Trauma, and BEST, are available, but data remain limited beyond learner self-assessment surveys. Survey results by Jacobs et al[19] of postcourse data exhibited a significant self-assessed improvement in ability to identify and repair traumatic injuries following ATOM. A follow-up study in 2014 showed that despite variable resident pre-course exposure to trauma there were similar precourse and postcourse improvements in knowledge and self-efficacy after ATOM ($P < .0001$).[20]

How can these challenges be best addressed by training programs, faculty, and surgical educators intent on maintaining vascular trauma care within the national landscape? One understanding is that not all challenges are negative for overall patient care, even if they do suggest substantial change from prior surgical training. Multispecialty teams are well-suited to the multimodal and hybrid approach to traumatic injuries that were previously relegated to high morbidity open operations or nonoperative status. With this shift come learners of other specialties that engage in this complex care, and reflexively we should expand global assessment of competency, simulation, and preparation courses to deal with these complicated repairs accordingly. Although simulation is a worthwhile educational adjunct to adjust to changing times, data are lacking on long-term impact beyond perceived learner confidence and self-efficacy surveys. This factor is true of most educational training methods that are unable to show higher levels of effectiveness owing to limited assessment and evaluation tools to measure enduring outcomes. That does not necessarily implicate a lower standard, but rather a lack of data support for its impact and usefulness, especially for charged trauma scenarios that, even in the highest fidelity simulators, may lack similarity to real-life high-energy trauma injuries and modern-day mass casualty events.

Driven by a focus on care data, management has moved to less overall operative trauma volume. Although vascular fellows and integrated vascular residents may be making up for this deficit in increased endovascular volumes, GSRs have clearly born the burden of this shift unequally. Relevant reviews of access to surgical care have offered insights that reveal that rural access is decreasing and, with it, program complements have remained stagnant at counterpart urban centers where volumes have increased. This then means less trainees for overall increased volumes and more demands on training away from trauma care. Furthermore, trauma status designation offers some degree of additional variability to operative trauma experience across national programs. These implications seem to coalesce to an understanding in surgical education that we must do more with less—less hours, less case volume, less training centers and hospitals, less trainees per case, and less time per learner. As suggested here, the roles of high-fidelity simulation, trauma preparation courses, a collaborative team approach, effective institutional injury triage, and proper specialty selection for optimal repair all have an impact on the future treatments of vascular trauma.

DISCLOSURES

None.

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