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## Trends in open vascular surgery for trauma: implications for the future of acute care surgery

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### ABSTRACT

**Background:** Trauma patients with vascular injuries have historically been within a general surgeon's operative ability. Changes in training and decline in operative trauma have decreased trainees' exposure to these injuries. We sought to determine how frequently vascular procedures are performed at US trauma centers to quantify the need for general surgeons trained to manage vascular injuries.

**Methods:** We conducted a retrospective analysis of the National Trauma Data Base (NTDB) from 2012 compared with 2002. Patients with general surgical and vascular procedures were identified using International Classification of Diseases, Ninth Revision, procedure codes 38.0-39.99, excluding 38.9-38.99.

**Results:** General surgery or vascular operations were performed on 12,099 (24%) of 50,248 severely injured adult patients in 2002 and 21,854 (16%) of 138,009 injured patients in 2012. Nineteen percent to 26% of all patients underwent vascular procedures. Patients with combined general surgery and vascular procedures were less likely to be discharged home and more likely to die. In 2002, 6% of severely injured adult trauma patients underwent open vascular procedures at level III/IV trauma centers; by 2012, only 1% of vascular surgery procedures were performed at level III/IV centers ( $P < 0.001$ ).

**Conclusions:** Need for emergent vascular surgery remains common for severely injured patients. Future trauma systems and surgical training programs will need to account for the need for open vascular skills. The findings suggest that there is already a trend away from open vascular procedures at level III/IV trauma centers, which may be a sign of system compensation for changes in the workforce.

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### Introduction

Trauma patients with vascular injuries requiring operative intervention have historically been within the purview of a

general surgeon's operative ability. However, vascular surgery training and treatment have been evolving rapidly in the last decade, including receiving approval from the American Board of Medical Specialties to become its own specialty.

Paper was presented at the American Association for the Surgery of Trauma (September 2015).

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Thus, many vascular surgery programs developed primary vascular surgery residencies directly from medical school. As a result, training of general and vascular surgeons has changed with vascular residents getting less general surgery training and general surgery residents often getting less vascular training.<sup>1-3</sup> There has also been a steady decline in operative trauma overall in the past 20 y, a decline that includes vascular cases.<sup>4</sup> In addition, many injuries previously treated with an open procedure are now being managed using endovascular techniques.<sup>5</sup> These changes have led to a training environment in which general surgery residents receive infrequent open vascular operative experience; these are the same residents who are often tasked with caring for the injured during and after their training.

Practicing general surgeons must be prepared to deal with the urgent care of vascular injuries in trauma patients in settings without endovascular capacity. This presents a paradox: how will surgeons manage increasingly rare, but potentially serious, vascular injuries if there is little or no training in their management? To quantify this need, we sought to determine how frequently vascular procedures are performed at US trauma centers and compare this to historical controls. We hypothesized that urgent vascular surgical cases represent a substantial proportion of operative trauma cases. We further hypothesized that as expertise in open vascular operations changes, patients who require vascular surgery operations may be more likely to concentrate in an American College of Surgeon (ACS)-verified level I/II versus level III/IV trauma centers.

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## Methods

We conducted a retrospective analysis of the National Trauma Data Base (NTDB) from 2012. Historical comparisons were made using NTDB 2002. Patients with general surgical and vascular procedures were identified using the International Classification of Diseases, Ninth Revision, Clinical Modification procedure codes. Patients were included if they were adults (age  $\geq 18$  y), had an injury severity score (ISS)  $>15$ , and if they underwent either a general surgery or open vascular operation. Patients were excluded if the operation occurred after 24 h as it would be more difficult to determine the emergent need for the operation. General surgery cases were identified using procedure codes 41.1 to 54.99. Open vascular surgery cases were identified using procedure codes 38.0-39.99, excluding 38.9-38.99.

Variables used in the analysis included: age, gender, region, ISS, ACS trauma center level, hospital bed size, procedure type, discharge, and mortality. Statistical analysis was performed using STATA/SE (version 14) with chi-square, or analysis of variance used where appropriate. The study was waived by the institutional review board as it was determined that the deidentified data did not constitute a need for institutional review board approval.

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## Results

In 2002, a total of 50,248 severely injured adult patients were included in the analysis. Of those, 12,099 (24%) patients

underwent a vascular or a general surgical operation (Table 1). A total of 7175 patients (59% operative cases, 14% all patients) underwent a general surgery procedure, 2322 patients (19% operative cases, 5% all patients) underwent a vascular procedure, and 2602 patients (22% operative cases, 5% all patients) underwent both a general surgery and vascular procedure. Age, gender, and ISS were statistically different between those patients who underwent a general surgery procedure, a vascular procedure, or both, although patients were generally males in their fifth decade ( $P < 0.001$ ).

In 2012, there were 138,009 severely injured adult patients included in the analysis (Table 2). Of those, 21,854 (16%) patients underwent one or more procedures of interest. Of this group, 12,281 patients (54% operative cases, 9% all patients) underwent a general surgery procedure, 5087 patients (26% operative cases, 4% all patients) underwent a vascular procedure, and 4486 patients (20% operative cases, 3% all patients) underwent both a general surgery and vascular procedure. Age, gender, and ISS were statistically different between those patients who underwent a general surgery procedure, a vascular procedure, or both. Patients who underwent combined general and vascular surgery procedure had a higher ISS and were more likely to die (19%) compared with those patients with an isolated vascular or general surgery procedure (11% and 13%, respectively;  $P < 0.001$ ). Patients with both a vascular and general surgery procedure were also less likely to be discharged to home (25%) than their counterparts who received only a vascular or a general surgery procedure (37% and 35%, respectively;  $P < 0.001$ ).

Patterns in procedures performed were compared between 2002 and 2012. Over the observed period, there was little overall change in the age, gender, ISS, geographic distribution, morbidity, or mortality. Outcomes in 2002 resembled those in 2012, with patients having combined vascular and general surgery operations less likely to be discharged to home and more likely to die.

Whether cases were performed in level I/II centers versus level III/IV centers was also compared between the two study years. In 2002, 6% of severely injured adult trauma patients underwent an open vascular procedure at a level III/IV trauma center, and 94% underwent the procedure at a level I/II trauma center (Figure). In 2012, the proportion of patients undergoing a vascular surgery procedure at level III/IV centers decreased to 1% of all procedures ( $P < 0.001$ ; Figure).

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## Discussion

The need for emergent vascular surgery remains common for severely injured patients. Among US trauma centers included in the NTDB data set, a vascular surgery procedure was performed in 7%-10% of patients admitted. This is almost as common as emergent general surgical procedures, which were performed on 9%-14% of severely injured patients in the same set. This is true across US regions and at both high-volume trauma centers as well as lower volume centers. These findings have implications for the future training of general surgeons. With changes in general surgery training, general surgery residents are completing their training with

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