# The role of the vascular surgeon in anterior retroperitoneal spine exposure: Preservation of open surgical training

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***Objective:*** **Open vascular surgical procedures have decreased since the advent of endovascular repair. Advances in spinal fusion techniques and artificial disc replacement have led to an increase in the need for anterior retroperitoneal exposure of the lumbar spine (ARES). Vascular surgeons participate as "exposure surgeons" for these cases due to their unique skills in dealing with retroperitoneal structures. We report a single center experience with this procedure and focus on injury pattern and preservation of open surgical training.**

***Methods:*** **Patients undergoing ARES over an 8-year period were identified from our vascular registry. A two-team approach involving a vascular surgeon and spine surgeon has been routinely employed. ARES was performed for anterior lumbar interbody fusion or total disc replacement. The intraoperative techniques of vascular manipulation were reviewed. The need for suture repair of vascular structures and the incidence and timing of serious vascular injury was recorded.**

***Results:*** **Four-hundred and five ARES procedures were performed. The levels exposed included L5-S1 alone (128), L4-5 (54), 4-5 and 5-S1 (139), and other combinations in 84 cases. The exposure involved the L4-5 disc in 243 cases (60%). Exposure of L4-5 was accomplished above the left common iliac artery (CIA) in 44%, between the left CIA and common iliac vein (CIV) in 45%, and below the left CIV in 11%. Minor vascular injuries (all venous) needing suture repair occurred in 24% of cases overall. Minor vascular injuries occurred during both exposure (43%) and instrumentation (57%). Minor vascular injuries were significantly more frequent in cases involving the L4-5 disc than in those not involving L4-5 (31.7% vs 11.1%, $P < .001$). Serious, life-threatening, vascular injuries occurred in 12 patients (3%), all during instrumentation, and included left CIV laceration (seven cases), right CIV laceration (two cases), and inferior vena cava laceration, distal aortic plaque disruption and left CIA laceration in one case each. There was no association between body mass index, prior surgery, or type of instrumentation and the occurrence of minor or major vascular injuries. Postoperative vascular complications included three deep vein thromboses; two of which occurred in patients with CIV laceration.**

***Conclusion:*** **Vascular expertise is important in anterior retroperitoneal lumbar spine exposure. Minor venous injuries frequently occur during exposure and instrumentation. Significant vascular injuries, while rare, occur during instrumentation, therefore the vascular surgeon should remain present throughout the entire procedure. The vascular manipulations required during exposure of the L4-5 disc offer an excellent opportunity for open vascular surgical experience. Vascular surgeon involvement in these cases allows for prompt repair of vascular injuries and provides opportunities for the vascular surgery resident to augment his/her open surgical training. (J Vasc Surg 2009;50:148-51.)**

Open vascular surgical procedures have decreased over the last decade. This has occurred in the setting of an explosion of endovascular procedures including endovascular repair of aortic aneurysm (EVAR), visceral vessel interventions, carotid stenting, and peripheral vascular interventions. Vascular surgery fellowships are based in centers where EVAR, peripheral and visceral angioplasty, and stenting have become common practice. There has been a paradigm shift in the training of vascular surgery residents with endovascular procedures comprising a larger proportion of the surgical experience that these residents obtain in treating abdominal occlusive and aneurysmal disease.

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Competition of interest: none.

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0741-5214/$36.00



doi:10.1016/j.jvs.2009.01.007

Advances in spinal fusion techniques and artificial disc replacement have led to an increase in the need for anterior retroperitoneal exposure of the lumbar spine (ARES). Exposing the spine poses a risk for vascular injury necessitating operative repair. Hamdan et al recently reported an 11% incidence of major vascular injury in 480 patients undergoing spine exposure.[1] Vascular surgeons often are involved as "exposure surgeons" during these cases due to their unique skills in dealing with retroperitoneal structures, including the abdominal aorta and iliac vessels. We have explored our extensive experience with the two-team approach to anterior spine surgery, analyzed our injury pattern, and argue that this procedure provides ample opportunity for the general surgery and vascular surgery residents to increase their open vascular surgery experience.

## METHODS

Patients undergoing ARES over an 8-year period were identified retrospectively from our prospectively maintained vascular registry. Indications for ARES included degenerative disc disease, back pain, radiculopathy, spon-

dylolisthesis, pseudoarthrosis, infection, or tumor. Procedures included anterior lumbar interbody fusion, total disc replacement, or a combination of the two ("hybrid").

A two-team approach employing a vascular surgeon and spine surgeon was utilized in all cases. Either a third year surgical resident or a vascular resident was directly involved in the anterior spine exposure in all cases and actively contributed to the repair of vascular injuries. The decision for operation and type of procedure was determined by the spine surgeon. All patients were evaluated by the vascular surgeon prior to surgery. Procedures were performed via a left retroperitoneal approach with the patient in the supine position. A low, transverse, rectus-sparing incision was favored for exposures at L4-5 and L5-S1. A left, vertical, paramedian incision was preferred for levels involving L3-4 or L2-3. A lower midline incision was chosen when severe caudal angulation of L5-S1 was seen in patients needing multilevel exposure. Patients were seen postoperatively by the vascular surgery team while in the hospital. The inpatient follow-up included vascular and abdominal examinations, as well as a complete blood count on the first postoperative day. Duplex ultrasound of the lower extremities was ordered if the patient developed symptoms/signs of acute deep vein thrombosis (DVT); routine screening was not employed. After discharge, patients were only seen by the vascular surgeon if they developed specific vascular surgery complications, otherwise the spine surgeons provided long-term follow-up.

The intraoperative techniques of vascular manipulation were reviewed. The manipulation of the iliac vessels necessary for the exposure of the L4-5 disc was specifically recorded. The final exposure of the L4-5 disc was noted as being above (lateral to) the left common iliac artery (CIA), between the left CIA and common iliac vein (CIV), or below (medial to) the left CIV. A single exposure of L5-S1 required mobilization between the left CIA and CIV, while the others were performed between the left and right iliac vessels with ligation of the median sacral artery. L1-L2, L2-L3, and L3-L4 required little to no aortic/iliac mobilization. The need for suture repair of vascular structures and the timing (during exposure or during instrumentation) of vascular injury were recorded.

Vascular complications were reported intraoperatively, immediately postoperatively, and at 30-day follow-up. A minor vascular injury was defined as the need for fine monofilament suture repair. A major vascular injury was defined as any injury requiring more than simple suture repair (ie, lateral venorrhaphy, venous or arterial reconstruction, or suture ligation of major venous structure). The influence of level of spinal exposure, body mass index (BMI), prior abdominal surgery, and prior spine surgery on the incidence of minor and major vascular injury was evaluated.

Statistical analysis was performed with a software package (SPSS v.15, Chicago, Ill) using $\chi^2$ and paired *t* test. All statistics were considered significant at a $P < .05$. This study was approved by the Institutional Review Board at Loma Linda University Medical Center.

**Table I.** Demographic characteristics

| *Characteristics* | *Number of cases* | *Percentage* |
|---|---|---|
| Age | 48.08 ± 12.74 (15-82) | |
| Female:male | 229:176 | 56.5%/43.5% |
| CAD | 15 | 3.7% |
| DM | 35 | 8.6% |
| HTN | 110 | 27.2% |
| Smoking | 167 | 41.2% |
| PAD | 2 | 0.5% |
| Prior abdominal surgery | 181 | 44.7% |
| Prior posterior lumbar spinal surgery | 158 | 39.0% |
| Prior anterior spine surgery | 13 | 3.2% |
| Body mass index | 28.0 ± 5.3 (14.2-52.1) | |

*CAD,* Coronary artery disease; *DM,* diabetes mellitus; *HTN,* hypertension; *PAD,* peripheral arterial disease.

**Table II.** Indications for surgery and levels of exposure

| *Variable* | *Number of cases* | *Percentage* |
|---|---|---|
| Indication for surgery | | |
| Degenerative disc disease/back pain | 197 | 48.6% |
| Radiculopathy/spondylolisthesis | 157 | 38.8% |
| Pseudoarthrosis | 43 | 10.6% |
| Failed artificial disc | 4 | 1.0% |
| Infection | 3 | 0.7% |
| Tumor | 1 | 0.25% |
| Level of spinal surgery | | |
| L4-5 | 54 | 13.3% |
| L5-S1 | 128 | 31.6% |
| L4-5 & L5-S1 | 139 | 34.3% |
| Multiple including L4-5 | 50 | 12.3% |
| Multiple, not including L4-5 | 34 | 8.4% |

## RESULTS

Four hundred and five ARES procedures were performed from 2000 to 2008. The average age of patients undergoing ARES was 48. The study population included 176 men and 229 women. Other patient demographics are shown in Table I. The average BMI was 28. The indications for surgery and levels of exposure are demonstrated in Table II. Instrumentation performed included artificial disc replacement in 72 cases (alone or in conjunction with fusion) and anterior lumbar interbody fusion in 333 patients. A lower transverse abdominal incision was used in 346 cases (85.4%), a left vertical paramedian incision in 50 cases (12.3%), and a vertical midline incision in nine cases (2.2%). The exposure involved the L4-L5 disc in 243 cases (60%). Exposure of L4-5 was accomplished above the left CIA in 44% of cases, between the left CIA and CIV in 45% of cases, and below the left CIV in 11% of cases.

Minor vascular injuries requiring suture repair occurred in 95 cases (23.5%) (Table III). These injuries occurred during both the exposure (43%) and instrumentation (57%) portions of the procedures. All minor vascular inju-

**Table III.** Vascular injuries

| *Variable* | *Cases* | *Percentage* |
|---|---|---|
| Minor vascular injury | | |
| Overall | 95/405 | (23.5%) |
| Involving L4-5 | 77/243 | (31.7%) |
| Not involving L4-5 | 18/162 | (11.1%)[a] |
| At L4-5: | | |
| Exposure above | 18/107 | (16.8%) |
| Between | 49/109 | (45.0%)[b] |
| Below | 10/27 | (37.0%) |
| Major vascular injury | | |
| Overall | 12/405 | (3.0%) |
| Involving L4-5 | 10/243 | (4.1%) |
| Not involving L4-5 | 2/162 | (1.2%)[c] |

[a] $P < .001$.
[b] $P < .001$ between vs other.
[c] $P$ = ns.

**Table IV.** Minor and major vascular injuries

| *Minor vascular injury (N = 95)* | *Major vascular injury (N = 12)* |
|---|---|
| Left iliac vein (N = 95) | Left iliac vein (N = 7)<br>Right iliac vein (N = 2)<br>Left iliac artery (N = 1)<br>Aortic plaque rupture (N = 1)<br>IVC injury (N = 1) |

*IVC,* Inferior vena cava.

ries consisted of injuries to the left CIV or its tributaries. Minor vascular injuries were more common in exposures involving the L4-5 disc space than in cases not involving L4-5 (31.7% vs 11.1%, $P < .001$). The rate of injury at L4-5 was also influenced by the relationship of the exposure to the iliac vessels. Exposures between the left iliac artery and vein had a significantly higher rate of minor vascular injury (45.0% vs 20.9%, $P < .001$).

Major, life-threatening vascular injuries occurred in 12 patients (3%). All of these injuries occurred during spinal instrumentation and included left CIV laceration in seven cases (58%), right CIV laceration in two cases (16%), and inferior vena cava laceration, distal aortic plaque disruption, and left CIA transection in one case (8.3%) each (Table IV). The level of spinal exposure had no influence on the occurrence of major vascular injuries (Table III).

After performing a univariate analysis, there was no significant difference in BMI between groups with minor or major vascular injury and those without (28.9 vs 27.7, $P = .45$). Additionally, prior abdominal surgery had been performed in 44.7% of patients, yet this had no influence on the occurrence of any vascular injuries (26.5% vs 20.3%, prior surgery vs none, $P = .19$). The type of spinal reconstruction (disc/hybrid versus fusion) also had no influence on the incidence of vascular injury (30.6% vs 21.3%, $P = .09$). Finally, age and sex had no influence on injury pattern. Multivariate analysis was not performed due to lack of significance of the above variables.

Mean length of hospital stay was 5.5 days. The mean duration of postoperative ileus was 0.77 days. Perioperative complications included prolonged ileus in six patients (1.5%), arrhythmia/myocardial infarction in four patients (1.0%), deep venous thrombosis in three patients (0.7%), respiratory failure in three patients (0.7%), and urinary tract infection in two patients (0.5%). Of the three DVTs, two occurred in patients with CIV lacerations. There were no perioperative mortalities.

## DISCUSSION

Vascular surgery training has undergone a paradigm shift over the last decade. Prior to the advent of EVAR and endovascular procedures that address peripheral arterial disease and visceral disease, open abdominal vascular operations were frequently performed. This provided a rich surgical experience for vascular surgery residents as well as general surgery residents. Since the introduction of endovascular procedures into formalized vascular surgery training programs, there has been a concern that vascular surgery residents may not be able to obtain a sufficient volume of open abdominal procedures.

Cronenwett reported the change in vascular surgery training in the United States from 1994 to 2003.[2] Mean total operative volume per vascular surgery resident (VSR) increased over this time period while open procedures decreased by 12%. In 1994, the mean number of open elective repair of open infrarenal abdominal aortic aneurysms (AAA) was 20/VSR, this number increased to 31/VSR in 2000 prior to the advent of EVAR. By 2003, the number of open repairs had dropped to 18/VSR, while EVAR increased to 26/VSR.[2] This drop in open repair was relatively minor in this early study. However, over the past 5 years, the durability of endovascular abdominal procedures has been further solidified. Lin et al reported a significant 50% drop in open aneurysm repair from an annual number of 40/VSR to 19/VSR after introduction of EVAR.[3]

Over the past decade, we have observed a dramatic decrease in the number of open abdominal operations in our training program. Ninety percent (90%) of aneurysm repairs are performed via an endoluminal approach, with most of the open experience coming from patients that present with ruptured, juxtarenal, or suprarenal aortic aneurysms. Due to similar trends in endovascular interventions, most open visceral operations at our institution are now performed for debranching procedures for complex EVAR or TEVAR. Our experience is in contrast to reports from other institutions that the open aneurysm volume remained stable after introduction of EVAR at their institution, while their EVAR volume increased dramatically.[4,5]

In an era in which open experience can be highly variable, other abdominal procedures will be necessary to help vascular surgery residents gain experience with identifying the vascular anatomy, surgical technique of abdominal vessel dissection, as well as with handling vascular injury. Fortunately, in the last decade, anterior retroperito-

neal lumbar spine exposure has offered vascular surgeons such an opportunity.

Anterior spine exposure requires that the surgeon be familiar with the anatomy of the retroperitoneum including the major vascular structures. The approach is retroperitoneal and utilizes all the techniques used to expose the aorta during open aneurysm repair. Exposure requires identifying and entering a retroperitoneal plane, recognizing and preserving the major retroperitoneal structures including the ureter, distal aorta, and iliac vessels. The anterior approach to L4-5 uniformly requires some manipulations of the iliac vessels. In the current study, the iliac vessels needed to be extensively mobilized in 89% of cases, and the iliac artery and vein had to be dissected separately in 45% of cases. Additionally, suture repair of vessel injury (all venous) was necessary in 23.5% of cases. The occurrence of these minor injuries equally during both exposure and instrumentation highlights the need for vascular surgeon involvement throughout the entire procedure.

Major vascular injuries during anterior retroperitoneal spine exposures occurred in three percent of the cases in our experience. These major injuries all occurred during instrumentation and required immediate attention. This again underlines the importance of vascular surgeon involvement and availability throughout the procedure.

Surgical residents and vascular surgery residents were directly involved in all spine exposures and either performed or assisted with the mobilization of vessels and repair of vascular injuries. Through these experiences, the residents were able to develop skills in hemorrhage control, vessel dissection and mobilization, as well as suture repair of injured vascular structures. Additionally, they were able to become facile at obtaining exposure of the vital retroperitoneal structures. Clearly, the experience gained by the trainee in vascular manipulations during spine exposures will ensure the ability to successfully repair these injuries and these skills are directly transferable to other abdominal vascular procedures.

Our findings are in line with the recent report by Hamdan et al with some important differences. Hamdan et al reported on 408 anterior exposures with a two percent rate of major vascular injuries.[1] The authors found that most injuries occurred during exposure, however, in our series all major vascular injuries occurred during the instrumentation portion of the procedure. Also, our preferred incision is transverse, while the Hamdan group prefers the vertical midline approach. Prior abdominal surgery having no effect on vascular injury is an important finding in our current study which was not assessed in the other report.

The overall complication rate during spine exposure has been reported to be as high as 40%.[6] Holt et al report a lower intraoperative complication rate and decreased blood loss when spine surgery was performed by a senior spine surgeon, in comparison to a spine surgeon and an "exposure surgeon" (either a vascular surgeon or general surgeon) in their series of over 400 patients.[7] However, in our own institution the involvement of the vascular surgeons was elicited by the spine surgeons to minimize such injuries.[8] Indeed, with the newer technologies of artificial disc replacement, the involvement of an exposure surgeon was common in the clinical trials and is mentioned in the current instructions for use. The artificial discs require greater side-to-side exposure of the disc spaces and often more mobilization of the iliac vessels than during fusion procedures. A surgeon with vascular expertise is therefore important and, thus, adds to patient safety during spine surgery.

## CONCLUSION

While abdominal endovascular procedures have become a routine procedure, there continues to be a need for the vascular surgeon to handle a variety of complex open intra-abdominal vascular emergencies and pathologies. Anterior retroperitoneal exposure of the lumbar spine allows the vascular surgery resident to augment his/her surgical experience of exposing, mobilizing, and repairing major abdominal vascular structures in an era of decreased open abdominal experience. Additionally, involvement of the vascular surgeon in spinal surgery contributes to the immediate and efficient repair of vascular injuries. Anterior retroperitoneal exposure of the lumbar spine should be considered an important addition to vascular training as a way to maximize open surgical experience.

## AUTHOR CONTRIBUTIONS

Conception and design: AA, OU, WZ, WC
Analysis and interpretation: AA, JC
Data collection: AA, OU
Writing the article: JC
Critical revision of the article: JC, AA, WZ, WC, OU
Final approval of the article: JC, AA, WZ, WC, OU
Statistical analysis: JC, AA
Obtained funding: Not applicable
Overall responsibility: AA

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Submitted Nov 19, 2008; accepted Jan 3, 2009.