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ORIGINAL ARTICLE

Access related complications in anterior lumbar surgery performed by spinal surgeons

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Abstract
Purpose Anterior lumbar surgery is a common procedure for anterior lumbar interbody fusion (ALIF) and artificial disc replacement (ADR). Our aim was to study the exposure related complications for anterior lumbar spinal surgery performed by spinal surgeons.
Methods A retrospective review was performed for 304 consecutive patients who underwent anterior lumbar spinal surgery over 10 years (2001–2010) at our institution. Each patient's records were reviewed for patients' demographics, diagnosis, level(s) of surgery, procedure and complications related to access surgery. Patients undergoing anterior lumbar access for tumour resection, infection, trauma and revision surgeries were excluded.
Results All patients underwent an anterior paramedian retroperitoneal approach from the left side. The mean age of patients was 43 years (10–73; 197 males, 107 females). Indications for surgery were degenerative disc disease (DDD 255), degenerative spondylolisthesis (23), scoliosis (18), iatrogenic spondylolisthesis (5) and pseudoarthrosis (3). The procedures performed were single level surgery—L5/S1 ($n = 147$), L4/5 ($n = 62$), L3/4 ($n = 7$); two levels—L4/5 and L5/S1 ($n = 74$), L3/4 and L4/5 ($n = 4$); three levels—L3/4, L4/5, L5/S1 ($n = 5$); four levels—L2/3, L3/4, L4/5, L5/S1 ($n = 5$). The operative procedures were single level ADR ($n = 131$), a single level ALIF ($n = 87$) with or without posterior fusion, two levels ALIF ($n = 54$), two levels ADR ($n = 14$), a combination of ADR/ALIF ($n = 10$), three levels ALIF ($n = 1$), three levels ADR/ALIF/ALIF ($n = 1$), ADR/ADR/ALIF ($n = 2$), four levels ALIF ($n = 1$) and finally 3 patients underwent a four level ADR/ADR/ALIF/ALIF. The overall complication rate was 61/304 (20 %). This included major complications (6.2 %)—venous injury requiring suture repair ($n = 14$, 4.6 %) and arterial injury ($n = 5$ [1.6 %], 3 repaired, 2 thrombolysed). Minor complications (13.8 %) included venous injury managed without repair ($n = 5$, 1.6 %), infection ($n = 13$, 4.3 %), incidental peritoneal opening ($n = 12$, 3.9 %), leg oedema ($n = 2$, 0.6 %) and others ($n = 10$, 3.3 %). We had no cases of retrograde ejaculation.
Conclusion We report a very thorough and critical review of our anterior lumbar access surgeries performed mostly for DDD and spondylolisthesis at L4/5 and L5/S1 levels. Vascular problems of any type (24/304, 7.8 %) were the most common complication during this approach. The incidence of major venous injury requiring repair was 14/304 (4.6 %) and arterial injury 5/304 (1.6 %). The requirement for a vascular surgeon with the vascular injury was 9/304 (3 %; 5 arterial injuries; 4 venous injuries). This also suggests that the majority of the major venous injuries were repaired by the spinal surgeon (10/14, 71 %). Our results are comparable to other studies and support the notion that anterior access surgery to the lumbar spine can be performed safely by spinal surgeons. With adequate training, spinal surgeons are capable of performing this approach without direct vascular support, but they should be available if required.

Keyword Anterior lumbar · Vascular injury · Complications

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Introduction

The anterior approach to the lumbar spine has been shown to be versatile allowing excellent exposure, visualisation

and importantly space to perform the procedure being undertaken. In anterior lumbar surgery, there is no disruption of the paravertebral muscles and ligaments. This approach is, therefore, commonly used for the treatment of degenerative disc disease (DDD), spondylolisthesis, tumour, infection and fracture. With further development of bone graft substitutes and disc replacements, this exposure promises further growth.

The retroperitoneal approach, which we favour, is performed through a paramedian incision (rather than anterolateral). The anterior rectus sheath is incised, the rectus muscle retracted laterally to allow exposure of the peritoneum (with the arcuate ligament incised as required). This technique protects the nerve supply to the rectus muscle. The left ureter and peritoneal contents are mobilised away from the psoas muscle; deeper retractors inserted and mobilisation of the common iliac vein/artery and/or aorta and vena cava were performed depending on the disc space of interest. Ligation of the middle sacral vessels (for L5/S1 exposure), iliolumbar vein (for L4/5 exposure) and segmental arteries/veins (allowing more proximal access) is performed as necessary [1].

One of the major concerns to this approach is the potential risk to retroperitoneal and intra-peritoneal structures. In particular, vascular injury would appear to be the most common with a reported incidence ranging from less than 1 % to almost 15 % (based on the inclusion/exclusion criteria as to what classifies for this) [1–4]. As a result, some have advocated for the use of a multidisciplinary surgical team with a vascular or 'access' surgeon [5]. Others have reported success with acceptable complication rates when this approach is performed by spinal surgeons alone [6, 7].

There would appear to be some lack of data on detailed reporting of complication rates with this approach. Further, clarification for medico-legal purposes is also useful. This study looks at our experience of anterior lumbar surgery (with regards to anterior lumbar interbody fusion [ALIF] and/or artificial disc replacement [ADR]) performed exclusively by spinal surgeons.

Materials and methods

We conducted a retrospective review of all patients receiving anterior lumbar spine surgery from L2 and below over 10 years (2001–2010) by all spinal surgeons at our institution. Procedures were performed by, or under the direct supervision of a Consultant Spinal Surgeon. This access to the lumbar spine was performed by the spinal surgeon without the assistance of a vascular "access" surgeon in all cases. Each patient's records (including anaesthetic charts and operative records) were reviewed for patients' demographics, diagnosis, level(s) of surgery, procedure and complications related to the access surgery. Each patient's notes were studied in detail by an independent research fellow (MK) and then this data were further analysed by another spinal fellow (SB). Patients who underwent surgery for tumour resection, infection, trauma and revision procedures were excluded from the study due to the variability of pathology and the surrounding structures, which could influence outcomes.

Definitions of a complication were set purposely harshly, so as to present data that is as critical as possible. We defined a major vascular injury as any case where a suture was required to control bleeding or those requiring vascular reconstruction [6]. All patients underwent a traditional paramedian incision with retroperitoneal dissection for the anterior spine approach as previously described [1, 8]. A subset of patients also underwent posterior spine surgery immediately after the anterior surgery as a single stage procedure.

It must be noted that a vascular surgeon was always available in the hospital in the event that the spinal surgeon required assistance with a vascular injury. In the United Kingdom, it is usual to operate in this manner, with the pressures of funding and list availability precluding a vascular surgeon being present in theatre just in case their assistance is required.

Finally, this investigation was deemed exempt from ethics approval as per institutional guidelines on service evaluation. Statistical analysis was performed using SPSS 17.0 version software (Statistical Package for Social Sciences, SPSS Inc.). Student's t test was used to analyse the statistical significance. p values less than or equal to 0.05 were considered significant.

Results

During the 10-year study period, a total of 304 patients fitted the inclusion criteria. The mean age of patients was 43 years (10–73; 197 males, 107 females). Indications for surgery (Table 1) were DDD ($n = 255$), degenerative spondylolisthesis ($n = 23$), scoliosis ($n = 18$), iatrogenic spondylolisthesis ($n = 5$) and postero-lateral pseudoarthrosis ($n = 3$).

The majority of patients had single level surgery—147 patients had surgery at the L5/S1 level, 62 patients at L4/5 and 7 patients at L3/4. Seventy-eight patients had two level surgery—the vast majority of which had L4/5 and L5/S1 surgery ($n = 74$), the remainder were at L3/4 and L4/5 levels. Five patients had three level surgery at L3/4, L4/5 and L5/S1, whilst 5 patients had four level surgery from L2/3 to L5/S1 (Table 2).

The anterior procedures performed are listed in Table 3. One hundred and thirty-one patients had a single level

Table 1 Indications for anterior spinal surgery

Indication	No.	%
Degenerative disc disease	255	84
Degenerative spondylolisthesis	23	8
Scoliosis	18	6
Iatrogenic spondylolisthesis	5	2
Pseudoarthrosis	3	1

Table 2 Levels of anterior lumbar spinal surgery

No. of levels	No.	%
One	216	71
Two	78	26
Three	5	2
Four	5	2

ADR and 87 patients underwent a single level ALIF with or without posterior fusion. Fifty-four patients had two levels ALIF, 14 patients had two levels ADR, whilst 10 patients received a combination of ADR/ALIF. Complexity further increased with 1 patient undergoing a three levels ALIF, 1 who had a three levels ADR/ALIF/ALIF, 2 patients having ADR/ADR/ALIF, 1 patient had four levels ALIF and finally 3 patients underwent a four level ADR/ADR/ALIF/ALIF.

The overall complication rate was 20 % (61/304) and these are further broken down to major and minor complications in Table 4. The commonest complications encountered were of vascular origin. Venous injury had a rate of 6.3 % ($n = 19$)—14 of these venous injuries required repair (4.6 %), the remainder were treated with conservative measures including haemostatic agents and tamponade. Arterial injuries occurred in 1.2 % of patients ($n = 5$), 3 of which were repaired and 2 were thrombolysed. Nine of the 14 patients who had their venous injury (left common iliac vein) repaired had surgery at the L4/5 level (64 %). An even higher ratio was seen in those who needed arterial intervention with 4 of the 5 patients having surgery at L4/5 (80 %).

When we further explored patients who had suffered a major venous injury (Table 5), the mean operative time taken for operation requiring venous repair was significantly longer than those with no venous injury (260 vs. 185 min, $p < 0.01$). The operative time for cases with venous injury not requiring repair was not significantly different to those with no venous injury (238 vs. 185 min, $p > 0.05$). Those who underwent venous repair had a statistically higher mean blood loss (1,750 ml, $p < 0.0005$) compared to the other groups, with mean blood loss without venous injury being 361 ml, and with conservatively managed venous injury being 425 ml. Four out of 14 (29 %) venous repairs required vascular surgical assistance; the remainder were sutured by the spinal surgical team (10/14, 71 %).

The overall infection rate was 4.3 % ($n = 13$; superficial [3.4 %], deep [1 %]); the peritoneum was incidentally

Table 3 Type of anterior procedure

Anterior procedure	No.	%
Single level ADR	131	44
Single level ALIF	87	29
Two levels ALIF	54	18
Two levels ADR	14	5
Two levels ADR/ALIF	10	3
Three levels ALIF	1	0.3
Three levels ADR/ALIF/ALIF	1	0.3
Three levels ADR/ADR/ALIF	2	0.6
Four levels ADR/ADR/ALIF/ALIF	3	1
Four levels ALIF	1	0.3

Table 4 All Complications

Type of Complication	No.	%
Major		
Venous injury requiring repair	14	4.6
Arterial injury	5	1.6
Direct repair	3	1
Thrombolysis	2	0.7
Minor		
Venous injury managed conservatively (haemostatic agent, pressure)	5	1.6
Infection	13	4.3
Incidental peritoneal opening	12	3.9
Post-operative leg oedema	2	0.6
Other (incisional hernia, ileus)	10	3.3
Overall	61	20

Table 5 Comparisons of operative time and blood loss with/without venous injury

Venous injury (No., %)	Mean operative time (min)	Mean blood loss (ml)
No vascular injury ($n = 280$, 92.2 %)	185	361
Venous injury managed with conservative measures ($n = 5$, 1.7 %)	238 ($p > 0.05$)	425 ($p > 0.05$)
Venous injury managed with suture repair ($n = 14$, 4.6 %)	260 ($p < 0.01$)	1750 ($p < 0.0005$)

opened in 3.9 % ($n = 12$); 0.6 % ($n = 2$) suffered post-operative leg oedema. No patients developed retrograde ejaculation and 3.3 % had other complications (incisional hernia or a conservatively managed ileus).

Discussion

We report a very thorough and critical review of our anterior lumbar access surgeries performed mostly for DDD and spondylolisthesis at L4/5 and L5/S1 levels. Our rate of vascular injury was 7.8 %—the majority of the venous injuries (including repair) were managed by the spinal surgeon without any sequalae. Our incidence of major venous injury requiring repair was 4.6 % and arterial injury 1.6 %. Our overall number of cases requiring vascular assistance was 9/304, at a rate of 3 % (5 arterial and 4 major venous injuries).

Technologies have improved making anterior surgery a more viable option, and anterior lumbar spine procedures have thus become increasingly popular amongst spinal surgeons [9–15]. Initially, there was a debate as to who best should provide access to this region, largely arising in the context of medico-legal concerns, given the attendant risks to retroperitoneal or intra-peritoneal structures that might require urgent assistance from a colleague in the respective surgical discipline. There was, therefore, an argument to enlist the help of an "access" surgeon [16], but in this institute, spinal surgeons have always undertaken this approach. This debate has largely been resolved with Jarrett et al. [6] who reported no significant difference between the rate of intra-operative complications in cases performed with and without an access surgeon. These findings were recently confirmed by Smith et al. [7] who found that the rate of complications was in fact significantly lower in those cases performed solely by a spinal surgeon when compared to those with an access surgeon. These papers largely, we feel, counter arguments such as those of Ikard [5] who recommended assistance from an access surgeon, as he felt that spine surgery training programmes did not teach their residents to expose, protect or repair viscera or vessels.

With regards to previously reported complication rates for anterior spinal surgery, there are somewhat differing reports. Brau et al. [4] reported a rate of vascular injury of 1.9 % in 1,315 cases performed by an access surgeon, the majority of which were at L4/5—6 patients were identified as having left major artery thrombosis (0.45 %) and 19 had major vein lacerations (1.4 %). They comment that lacerations of 4 mm or less can be controlled by haemostatic agents and may not require suture repair. However, the number of patients with venous bleeding managed in this fashion is not reported and neither are other complications. We have previously described our approach and strategies for dealing with arterial injury [17].

A review by Inamasu and Guiot [9] quoted the incidence of vascular complications as being between 0 and 18.1 %. Intra-operative vascular injury (defined as any case in which a suture was used to control bleeding) occurred in 11 % of 480 patients reported by Hamdan et al. [1] who again noted an increased rate of complication at the L4/5 level. One might expect a higher rate of complications in revision surgery and this is supported by the literature (and which we have excluded). Brau et al. [10] report a series of 62 patients undergoing a revision anterior approach, with a vascular complication rate of 9.7 %, approximately 5 times the complication rate previously reported by the same author in primary surgery. This included a 4.8 % rate of arterial injury, some 10.6 times higher than their previously published results. There was also 1 ureteral injury and 1 case of retrograde ejaculation. Recommendations for revision surgery include an opposite side retroperitoneal approach at L5/S1 and an anterolateral retroperitoneal approach for higher levels, staying lateral to previous dissection. Complications other than those to vascular structures are poorly reported. Smith et al. [7] include rates of complications such as incisional hernias, ileus and peritoneal rent, both with and without an access surgeon. Their reported rates of ileus are far greater with an access surgeon, at 58 %, compared to 2.6 % with a spinal surgeon alone. Our ileus rate of 2 % would appear to confirm their findings. An incisional hernia rate of 0.7 % in our study compares favourably to Smith's figures at 21–37 %. Additionally, we had no patients who developed retrograde ejaculation, with the previously reported incidence at 0.44–25 % [5]. Many surgeons would consider some of our listed complications as not being complications at all; for instance, incidental peritoneal opening. We have, however, attempted to provide a full disclosure of all perceived complications. In addition, our study has been strengthened by the fact that it was an independent, as well as quite exhaustive review of original records and data by 2 fellows.

Finally, it is worth noting, that all operations in our series were performed by fully fellowship trained spinal surgeons (with varying experience) or directly under their supervision. We have all had training through general surgical training programmes and/or live tissue training with vascular injuries and repair (https://aospine2.aofoundation.org/strasbourg/). We further revalidate (and update) these skills by running yearly anterior exposures courses involving cadaveric training and live surgeries (http://nottinghamspine.co.uk/docs/2012Programme.pdf). In our opinion, performing between 25 and 30 cases with an experienced spinal surgeon would be reasonable for trainees to demonstrate competency and allow independent operating. We additionally perform fairly robust 6 monthly

appraisals of all our fellows in performing these and other procedures [18]. With adequate training and judgment, spinal surgeons can safely perform such exposures, provided vascular surgical assistance is readily available if required. One should employ particular care with surgical exposures at the L4/5 level. We continue to selectively recruit the assistance of our vascular surgical colleagues for cases, such as revision surgery, and in which exposure may be anticipated to be difficult.

Conclusion

Our results are comparable to other studies and support the notion that anterior access surgery to the lumbar spine can be performed safely by spinal surgeons. With adequate training, spinal surgeons are capable of performing this approach without direct vascular support, but they should be available if required, with vascular surgical assistance required in 3 % of our cases.

Conflict of interest None.

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