Analysis of intraoperative difficulties and management of operative complications in revision anterior exposure of the lumbar spine: a report of 25 consecutive cases

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Abstract

Purpose After a first anterior approach to the lumbar spine, formation of adhesions of soft tissues to the spine increases the surgical difficulties and potential for iatrogenic injury during the revision exposure. The objective of this study was to identify the intraoperative difficulties and postoperative complications associated with revision anterior lumbar spine procedures in a single institution.

Methods This is a retrospective review of 25 consecutive anterior revision lumbar surgeries in 22 patients (7 men and 15 women) operated on between 1998 and 2011. Patients with trauma or malignancies were excluded. The mean age of the patients at the time of revision surgery was 56 years (range 20–80 years). The complications were analyzed depending on the operative level and the time between the index surgery and the revision.

Results Six major complications (five intraoperatively and one postoperatively) occurred in five patients (20 %): three vein lacerations (12 %) and two ureteral injuries (8 %), despite the presence of a double-J ureteral stent. The three vein damages were repaired or ligated by a vascular surgeon. One of the two ureteral injuries led to a secondary nephrectomy after end-to-end anastomosis failure; the other necessitated secondary laparotomy for small bowel obstruction.

Conclusions Anterior revision of the lumbar spine is technically challenging and is associated with a high rate of

vascular or urologic complications. Therefore, the potential complications of the procedure must be weighted against its benefits. When iterative anterior lumbar approach is mandatory, exposure should be performed by an access surgeon in specialized centers that have ready access to vascular and urologic surgeons.

Keywords Anterior approach revision surgery · Lumbar spine · Complications · Vein injury · Ureteral injury

Introduction

Anterior approach to the lumbar spine has become an increasingly popular procedure due to the increased use of anterior lumbar interbody fusion (ALIF) and artificial total disc replacement (TDR) [1, 2]. The complications associated with the anterior approach to the lower lumbar spine are summarized in Table 1. The incidence of vascular injury is estimated at 1.9–8 %, with the greatest risk at the L4–L5 level [3–5]. Ureteral injury during anterior lumbar arthrodesis has been reported in only a small number of cases [3, 5–11].

Revision surgery might be necessary in case of TDR failure, ALIF pseudarthrosis, infection or interbody device malposition or migration [12, 13]. The formation of adhesions of veins, arteries, ureter, nerve plexus, and peritoneum to the spine increases the potential for iatrogenic injury during the revision exposure [12]. The literature review found little data about complications related to revision anterior lumbar spine surgery [2, 9, 11, 13–18].

The purpose of this retrospective review was to identify the intraoperative difficulties and postoperative complications associated with revision anterior lumbar spine procedures in a single institution. The complications were

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Table 1 Summary of possible complications in revision anterior lumbar spine surgery and rate of complications in a series of 25 revision procedures

Complications	<i>n</i> (%)
Death	0
Acute decompensation of a pre-existing condition	0
Visceral injury ^a	4 (16 %)
Peritoneal laceration	3 (12 %)
Bladder injury	0
Bowel injury	0
Small bowel obstruction	1 (4 %)
Ureteral injury	2 (8 %)
Secondary nephrectomy	1 (4 %)
Vascular injury ^a	3 (12 %)
Veina cava	0
Aorta	0
Iliac veins or arteries	2 (8 %)
Left ascendant vein	1 (4 %)
Bleeding leading to transfusion	8 (32 %)
EBL (estimated blood loss) >500 mL	10 (40 %)
Iliac vein or deep vein thromboses	2 (8 %)
Pulmonary embolism	0
Mobilization of atherosclerotic plaques	0
Neurological injury	0
Retrograde ejaculation	0
Vasomotor sympathectomy	1 (4 %)
Deep infection involving the spine	0
Wound dehiscence/incisional hernia	0
Superficial parietal neuroma	0

^a Major complication related to the anterior spinal approach

analyzed depending on the operative level and the time between the index surgery and the revision.

Materials and methods

We retrospectively reviewed the medical records and radiographs of 25 consecutive revision lumbar spine procedures using the anterior approach in 22 patients operated on between 1998 and 2011. This was a single-center study. We only included patients that were treated initially for degenerative disc disease or isthmic spondylolisthesis and excluded from the series patients with trauma or malignancy.

One independent reviewer examined the operative notes, along with the anesthesia records. The following data were collected age, diagnosis, type of revision procedure, length of time between index and revision surgery, operative approach, operative time, blood loss, length of hospital stay, eventual abnormalities at the neurological

exam always performed and noticed before the patient left the hospital. Intra- and post-operative complications were noted and those, related to the anterior spinal approach, arbitrarily defined as major in case of damages on the intra-abdominal viscera or on the prevertebral great vessels (Table 1).

There were seven men and 15 women (Table 2). The mean age at the time of the index surgery was 52 years (range 20–76 years). Diagnoses of the original surgeries included degenerative disc disease ($n = 9$), degenerative spondylolisthesis ($n = 9$), isthmic spondylolisthesis ($n = 4$), and degenerative lumbar scoliosis with single level dislocation ($n = 3$). Primary surgeries were performed through a left retroperitoneal approach in most cases (Table 3).

The average time to revision was 5 years (range 1 week–35 years). The mean age of the patients at the time of revision surgery was 56 years (range 20–80 years). Eight early revision cases were performed within 3 months of the index surgery, all as a result of implant migration or early postoperative complication (Table 2). Late revision was required in 17 cases, mainly for adjacent disc disease (Table 2).

Nine patients underwent double-J ureteral stenting by an urologist prior to revision surgery. The different surgical approaches in index and revision surgeries are summarized in Table 3. In each case when a transperitoneal approach was used for revision, retroperitoneal dissection has been considered as not possible due to the scar tissue from the prior surgery.

Results

The average blood loss for the anterior revision procedure was 895 mL (range <50–4,400 mL). Blood transfusion (1–7 units) has been necessary in eight cases (32 %). The average operative time for the anterior revision procedure was 204 min (range 90–360 min). Table 4 summarizes the operative time and estimated blood loss for revision anterior lumbar spine surgery by type of revision (early or late). The average hospital stay was 29 days (range 7–90 days).

In two cases, anterior approach of the spine has not been possible. In one patient, inflammatory adhesions rendered dissection of the great vessels too difficult to access an infected disc prosthesis. Open debridement and drainage without implant removal was performed successfully. In another patient, access to the spine has not been possible, neither via a retroperitoneal nor via a transperitoneal approach due to soft tissues adhesions. Secondary spinal fusion was performed through a posterior approach.

There were no arterial injuries or intraoperative deaths. Six major complications occurred in five patients (20 %),

Table 2 Complete data set from 25 revision anterior procedures to the lumbar spine

Case no.	Age (years) (sex)	Index levels	Procedures	Indication for revision	Revision levels	Revision procedures	Time to revision	Approach/revision procedures	Ureteral stent	Intraoperative complications	Postoperative complications
1	35 (F)	L5–S1	ALIF	Implant migration	L5–S1	ALIF ^a	1.5 months	Transperitoneal	No	None	Temporary vaginal dryness
2	50 (F)	L5–S1	TDR	Radiculopathy due to implant malposition	L5–S1	TDR ^a	10 months	Transperitoneal	No	Common left iliac vein injury, repaired primarily	None
3	48 (F)	L4–L5	TDR	Implant migration	L4–L5	ALIF ^a	3 weeks	Transperitoneal	No	Common left iliac vein injury, repaired primarily	None
4	38 (F)	L4–L5	TDR	Implant subsidence (L4–L5)	L4–L5	ALIF ^a	1 week	Left retroperitoneal	Yes	None	None
5	47 (F)	L4–L5	ALIF	Pseudarthrosis	L4–L5	ALIF ^a	3 years	Left retroperitoneal	Yes	Iliolumbar vein injury, ligatured	Common iliac vein thrombosis
6	45 (M)	L4–L5	ALIF	Implant migration	L4–L5	ALIF ^a	3 months	Left retroperitoneal	No	None	None
7	47 (F)	L4–L5	ALIF	Infected pseudarthrosis	L4–L5	Implant removal ^a	2.5 years	Left retroperitoneal	Yes	None	None
8	58 (M)	L3–L4	ALIF	Adjacent level disease	L4–L5	ALIF ^a	12 years	Left retroperitoneal	No	None	Common iliac vein thrombosis
9	38 (F)	L4–L5	TDR	Infection	L4–L5	Debridement approach impossible to re move the implant	1 month	Left retroperitoneal	No	None	None
10	76 (M)	L4–S1	ALIF	Adjacent level disease	L3–L4	ALIF	35 years	Left retroperitoneal	No	None	Atrial fibrillation
11	54 (F)	L3–L4	ALIF	Adjacent level disease	L2–L3 L4–L5	ALIF	9 years	Left retroperitoneal	No	Peritoneal breach	None
12	37 (M)	L5–S1	TDR	Adjacent level disease	L4–L5	TDR	4 years	Left retroperitoneal	No	None	None
13	70 (F)	L4–L5	ALIF	Adjacent level disease	L2–L3 L3–L4	ALIF	3 years	Left retroperitoneal	Yes	None	None
14	64 (F)	L4–L5	ALIF	Adjacent level disease	L3–L4	ALIF	5.5 years	Left retroperitoneal	Yes	None	None
15	77 (F)	L4–L5	ALIF	Adjacent level disease	L3–L4	ALIF	3 years	Left retroperitoneal	No	None	None
16	41 (M)	L4–L5	ALIF	Adjacent level disease	L5–S1	TDR	10 years	Left retroperitoneal	No	None	None
17	48 (F)	L5–S1	TDR	Implant subsidence	S1–L5	ALIF	1 week	Left retroperitoneal	Yes	Peritoneal breach	Antibiotic-associated diarrhea urinary tract infection

Table 2 continued

Case no.	Age (years) (sex)	Index levels	Procedures	Indication for revision	Revision levels	Revision procedures	Time to revision	Approach/revision procedures	Ureteral stent	Intraoperative complications	Postoperative complications
18	57 (F)	L4–L5	ALIF	Radiculopathy due to implant malposition	L4–L5	Implant removal ^a	8 years	Left retroperitoneal	No	None	None
19 ^b	55 (F)	L3–L4	ALIF	Adjacent level disease	L2–L5	ALIF ^a	18 months	Left retroperitoneal	Yes	Ureteral injury	Acute renal failure failed anastomosis, infection, left nephrectomy
20 ^b	71 (F)	L4–L5	ALIF	Adjacent level disease	L3–L4	ALIF	18 months	Right retroperitoneal	No	None	None
21	60 (F)	L2–L4	ALIF	Adjacent level disease	L3–L4	ALIF ^a	3.4 years	Left retroperitoneal	Yes	None	None
22	51 (F)	L4–L5	ALIF	Adjacent level disease	L2–L3	Approach impossible	5.8 years	Transperitoneal	No	Approach impossible	None
23	59 (M)	L4–L5	ALIF	Adjacent level disease	L2–L5	ALIF ^a	14.8 years	Left retroperitoneal	No	Peritoneal breach	None
24 ^b	63 (F)	L3–L4	ALIF	Implant subsidence	L2–L5	ALIF ^a	2 months	Transperitoneal	Yes	Ureteral injury	Small bowel obstruction
25	20 (F)	L3–L4	ALIF	Nonunion	L3–L4	ALIF	3 months	Left retroperitoneal	No	None	None

ALIF anterior lumbar interbody fusion, TDR total disc replacement

^a Implant removal was necessary during revision^b Second revision surgery through an anterior approach

Table 3 Type of approach of the anterior lumbar spine during index and revision surgery

Index surgery	Revision surgery	<i>n</i> = 25
Left retroperitoneal	Left retroperitoneal	17
Transperitoneal	Transperitoneal	4
Transperitoneal	Left retroperitoneal	2
Left retroperitoneal	Right retroperitoneal	1
Left retroperitoneal	Transperitoneal	1

Table 4 Operative time and estimated blood loss (EBL) for revision anterior lumbar spine surgery by type of revision (early or late)

	Early revision (<3 months) (<i>n</i> = 8)	Late revision (>3 months) (<i>n</i> = 17)
Mean operative time (min)	189 ± 58	215 ± 81
Mean EBL ± SD (cc)	424 ± 556	808 ± 1,037

SD standard deviation

five intraoperatively and one postoperatively (Tables 1, 2). There were three cases with a vein laceration (15.8 %): two cases of tear in the left common iliac vein necessitating one unit of transfused blood in one case, and a case of tear in the iliolumbar vein necessitating seven units of transfused blood. The vascular complications all occurred during the time of exposure, when approaching the same vertebral level as the primary surgery with the same approach for the index surgery and the revision. Both tears in the left common iliac vein occurred during a transperitoneal approach to expose L4–L5 (one case) or L5–S1 (one case). The tear in the iliolumbar vein occurred during a second retroperitoneal approach to expose L4–L5. With the assistance of a vascular surgeon, the left iliac veins were sutured, and the iliolumbar vein was ligatured.

Two ureteral injuries occurred in two female patients despite the use of a double-J ureteral stent during the spine procedure. In both cases it was a third anterior approach, because of adjacent level disease in a degenerative lumbar scoliosis with single level dislocation at L3–L4 in one case, and cage subsidence at L3–L4 in the other. Noteworthy in their past history were rheumatoid arthritis, continuous treatment with steroids and multiple spine surgeries including anterior and posterior approaches. One injury was discovered on acute renal failure a week after the procedure. Entrapment of the left ureter by the internal fixation plate was diagnosed by CT urography (Fig. 1). After implant removal, ureteral injury was treated initially by ureteral resection and end-to-end anastomosis by a urological surgeon. An emergency left nephrectomy was secondary performed for uncontrolled severe sepsis due to failure of the anastomosis (ureteral necrosis). The other

injury (section of the left ureter) was diagnosed intraoperatively (Fig. 2), and treated by ureteral resection and end-to-end anastomosis by a urological surgeon. This patient developed small bowel obstruction postoperatively. After failure of nasogastric suction, she underwent exploratory laparotomy and had lysis of adhesions with a limited small bowel resection.

The five procedures with a major complication involved in all cases surgery at the same spinal level than the index one, and included, in all cases, implant removal (interbody cage or vertebral plate) which was performed with the same approach (trans- and/or retro-peritoneal) already used in the previous procedure.

Nine other complications occurred (Table 1). Despite prophylactic anticoagulation with low molecular weight heparins, two common iliac vein thromboses occurred, including one following venorrhaphy. Secondary pulmonary embolism did not occur and no cava filter has been implanted. No retrograde ejaculation was observed. One case of vaginal dryness, due to damage to the sympathetic system in a transperitoneal approach of L5–S1, resolved spontaneously in time. One acute postoperative atrial fibrillation, one nosocomial diarrhea due to *Clostridium difficile* and one urinary tract infection in a patient with a double-J ureteral stent were medically successfully treated. No deep wound infection involving the spine was observed.

Discussion

Anterior lumbar procedures (TDR and ALIF) have become increasingly prevalent in the surgical management of lumbar pathologies. The formation of adhesions after the primary surgery increases the potential for iatrogenic injury during the revision exposure [12]. If complications related to anterior exposure of the lumbar spine in primary surgeries have been well reported in the literature [1, 5, 19], only a few studies have reported the technical difficulties and the complications associated with revision surgeries through an anterior approach [2, 9, 11, 13–17].

The two main complications in our series are vascular injuries (12 %) and ureteral injuries (8 %). Previous studies have shown that vascular complications occurred in 0.4–15 % of primary ALIF procedures [3, 5, 20–23], whereas they occurred in 10–57 % in revision surgeries [13, 14, 16]. As in the three cases in our series, vascular injuries can occur during the surgical approach to the spine [13], but they can also happen while the discectomy (or implant removal) is being performed [5]. They are more frequent at L4–L5 than at L5–S1, because of the position of the iliac bifurcation and tethering of the iliolumbar vein [3, 5, 13]. In an attempt to avoid vascular injury and limit

Fig. 1 Eight days after revision anterior lumbar spine surgery for degenerative lumbar scoliosis with single level dislocation at L3–L4 (**a**), a CT urography is performed for suspicion of intraoperative ureteral injury. Entrapment of the left ureter under the internal fixation plate is visible on the 3D reconstruction of the spine and ureter (**b**) and on the axial view (*white arrow*) (**c**). Ureteral entrapment is confirmed intraoperatively (**d**)

blood loss during spine exposure, it is essential to obtain control of the vessels proximally and/or distally at previously nonoperated levels before mobilization of the vasculature and exposure of the target intervertebral level [13]. Vascular studies should be performed preoperatively to assess the position of the vessels [2, 12, 16]. We usually order a preoperative CT without injection, but with 3D reconstruction of the major vessels and lumbar spine to anticipate difficulties in the exposure (Fig. 3). Brau et al. [3] also use CT to assess the inflammation around the vessels and predict difficult dissection. Experienced access surgeons should be consulted [13, 24], especially if local conditions are not satisfactory (major adhesions, sepsis, L4–L5 or L5–S1 level, surgery at the same spinal level, necessity of implant removal). In our series, an orthopedic surgeon performed all the approaches, but a vascular

surgeon had to perform the three vascular repairs. Therefore, if data suggest that, with adequate training, spine surgeons may safely perform anterior spinal exposures in primary surgeries, provided vascular surgical assistance is readily available [25, 26], we recommend caution when attempting anterior revision surgery, especially for exposures of L4–L5 or L5–S1 where vessel injuries are more frequent.

Ureteral injuries have been reported in anterior lumbar spine surgery between 0.3 and 0.5 % of the cases, and in isolated cases occurring mainly during revision procedures [3, 7–11]. During anterior exposure, the ureter must be carefully identified to prevent iatrogenic injury. Authors agree that ureteral stenting should be performed to make the ureter a palpable retroperitoneal structure and enhance diagnosis of ureteral tear intraoperatively [2, 5, 16, 17]. In

Fig. 2 Intraoperative section of the left ureter was diagnosed fluoroscopically during a second revision surgery for cage subsidence and implant mobilization at L3–L4. Before section, anteroposterior (a) and lateral (b) views show a continuous double-J stent. After section, stent discontinuity is clearly visible (white arrows) (c), (d)

Fig. 3 A case of adjacent segment disease at L4–L5 after anterior lumbar spine fusion (a). Preoperative CT with 3D reconstruction of the great vessels and the spine is useful to anticipate difficulties and adhesions of the vessels to the anterior aspect of the lumbar spine (b)

our series, one patient has sustained a ureteral section and another a ureteral entrapment by an internal fixation plate, despite prior placement of a double-J ureteral stent. In the first case, it was diagnosed intraoperatively and end-to-end anastomosis could be performed successfully. However, in the second case, the injury was not diagnosed intraoperatively and despite a secondary anastomosis, subsequent

necrosis of the ureter resulted, eventually, in resection of the left kidney. If double-J ureteral stent may help identifying ureter during the surgical exposure, either manually or fluoroscopically, both cases demonstrate that it is not always sufficient to prevent its iatrogenic injury. Based on the results of this study, in revision surgeries, we regularly palpate the ureteral stents during the anterior lumbar spine

exposure, and at the time of implant positioning, to avoid its injury. Finally, we check its continuity and its position on a fluoroscopic control at the end of the surgery.

The use of a transperitoneal or a contralateral retroperitoneal approach has been suggested, as it bypasses the prior surgical path's adhesions [12, 27] and gives access to the spine through virgin tissue planes. However, the transperitoneal approach is associated with a significantly higher risk of retrograde ejaculation at L5–S1 level [28, 29] and to secondary small bowel obstruction due to intra-peritoneal adhesions. Furthermore, retroperitoneal right approach of the L4–L5 level is very difficult, because of the right iliac vein localization. The placement of an anti-adhesive membrane between the iliac vessels and the spine at the conclusion of the primary procedure may prove helpful in revision surgeries. It has been shown in two cases in the literature to make dissection, identification and protection of the left iliac vein easier [16, 17]. Above L5–S1, especially in case of adjacent level disease, an open lateral transpsoas approach can be performed [12, 16] with no need of dissecting adhesions and fibrous tissue between the spine and the great vessels [12].

Given the potentially life-threatening concerns surrounding revision anterior lumbar approaches, treating surgeons must strongly weight the different options in case of failure after an anterior spinal procedure. We have to distinguish cases, where posterior approach remains possible and cases where anterior approach seems mandatory for instance when a lumbar plate or an intersomatic implant removal is necessary, because of infection implant malposition or secondary mobilization with nervous or vascular impingement. As we confirm in our series, this situation is the most complex because complication rates are significantly higher for revision anterior lumbar surgeries at the same segment including implant removal, compared with cases involving adjacent segments [11].

Adjacent level disease can be treated with posterior approach to perform fusion or, in some cases, dynamic posterior stabilization. Therefore, it seems not reasonable to propose a disc arthroplasty, if an anterior procedure has been previously performed at an adjacent level. In case of ALIF nonunion, posterior osteosynthesis with pedicle screws combined with bone graft has to be preferred. In the present study, 15 revision procedures occurred for adjacent level disease or ALIF nonunion leading to 57.1 % (8/14) of the reported intra or postoperative complications (Table 2). In those 15 cases, the spinal disorder could have been treated through a posterior approach avoiding revision anterior surgery and its risks. In three other cases, secondary to subsidence, the implant encroached in the spinal canal in proximity to a nerve root. Then, its removal seemed to us necessary, leading to 28.6 % (4/14) of the reported complications. Some surgeons might have chosen

revision through a posterior approach, but it is difficult to know afterwards if this would have been more suitable procedure. In the seven last cases, revision anterior surgery was unavoidable, because of infection ($n = 2$) implant migration in anterior direction with impingement of the great vessels ($n = 3$) or implant malplacement with nerve root conflict ($n = 2$). Nevertheless, it led to two major vascular complications (14.3 %). Interestingly, the rate of complications in mandatory anterior revision surgeries was not worse than the rate of complications in avoidable anterior revision procedures. This reinforces the idea stated above that revision anterior surgery should be avoided whenever it is possible. Therefore, in cases where revision anterior approach is necessary, an access surgeon must perform the surgical approach except perhaps some very well trained and experienced spine surgeons, and a vascular surgeon has to be reachable and ready to intervene, if necessary. A ureteral double-J stent must be placed before surgery and regularly controlled by palpation and fluoroscopy. Therefore, revision anterior surgery of the lumbar spine is a multidisciplinary procedure that must be performed in specialized centers.

Although this was a retrospective chart review in a small series of patients, and therefore subject to the limitations of such studies, clinically useful information may still be obtained. Anterior revision of the lumbar spine is technically challenging, and the potential complications of the procedure must be weighted against its benefits. Many factors contribute to limit the risk of complications during the approach, including preoperative imaging studies of the great vessels, ureteral double-J stenting, the use of adhesion barriers during the index procedure or the presence of an experienced surgeon trained in anterior spine exposures. The possibilities of transpsoas approach in revision anterior lumbar spine surgery have yet to be explored. Nevertheless, in each case without necessity of implant removal, posterior approach can be considered to avoid taking undue risks related to anterior exposure of the spine.

Conflict of interest None.

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