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Anatomic basis of minimal anterior extraperitoneal approach to the lumbar spine

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Summary: Anterior lumbar spine approaches may be indicated for fusion in degenerative lumbar spine disorders or to fill discal and bone gaps after fracture reduction. We present an anterior extraperitoneal approach applicable to any discal and vertebral levels from T12 to S1. The anatomic study, based on 25 cadavers, highlights retroperitoneal dissection principles for easy kidney and duodenopancreatic mobilisation and direct left anterior access to the entire lumbar spine. We established a precise description of the lumbar veins and the anastomoses between the left renal vein and hemiazygos system, in order to define different topographic and anatomic factors related to safe and easily reproducible approaches for cage or graft implementation. Independent of the level and previous intraperitoneal surgery, lumbar spine access with this approach safeguards the kidney, ureter, spleen, hypogastric plexus and duodenopancreatic system. Regarding operating time, blood-loss and possibilities for freshening and grafting, this technique seems an effective counterbalance to the difficulties and complex technology of endoscopic approaches. The clinical study includes our first 42 cases in traumatic and degenerative lesions. Avoiding the neurologic or hemorrhagic risk inherent in classical posterior lumbar interbody fusion (PLIF) techniques, it can be considered as a reasonable and valid alternative. This technique could be used in the near future for mini invasive discal prosthesis insertion.

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Bases anatomiques de l'abord antérieur rétropéritonéal minimisé de la colonne lombaire

Résumé : Les abords antérieurs du rachis lombaire sont pratiqués pour l'obtention d'une fusion dans les cas de rachis dégénératif mais également pour combler des pertes de substance osseuse ou des vides discaux après les réductions de fracture. Nous présentons un abord antérieur extra-péritonéal applicable pour n'importe lequel des niveaux discaux et vertébraux de T12 à S1. L'étude anatomique basée sur 25 cadavres met en évidence les principes de la dissection rétropéritonéale pour une mobilisaion facile du rein et du bloc duodéno-pancréatique et un abord direct antéro-latéral gauche du rachis. Nous avons établi une description précise des veines lombaires et des anastomoses entre la veine rénale gauche et le système hémi-azygos dans l'optique de définir les différents facteurs topographiques et anatomiques indispensables à connaître pour un abord simple sécurisé et reproductible, et pour l'introduction de cages ou de greffes intersomatiques. Indépendamment du niveau à atteindre et des antécédents de chirurgie intra-péritonéale préalable, l'abord du rachis lombaire par cette technique ne pose pas de problème concernant le rein, l'uretère, la rate, le plexus hypogastrique et l'ensemble duodéno-pancréatique. Pour ce qui concerne la durée opératoire, le saignement et les possibilités d'avivement et de greffe, cette technique semble contrebalancer sérieusement les difficultés et la technologie complexe des abords endoscopiques. L'étude clinique rapporte nos 42 premiers cas de pathologie traumatique et dégénérative. Evitant le risque neurologique ou hémorragique inhérent aux techniques classiques de fusion intersomatique lombaire par voie postérieure, cet abord peut être considéré comme une alternative raisonnable et efficace. Cette technique pourrait être utilisée dans le futur proche pour l'insertion "mini-invasive" des prothèses discales.

Key words: Anatomy — Retroperitoneal anatomy — Extraperitoneal approach — Anterior lumbar interbody fusion

The anterolateral retroperitoneal approach to the lumbar spine is a classic technique for disc excision, grafting or vertebral resection, with or without channel exploration [31], but parietal muscular damage is a major problem which may impair the functional results [21]. The development of endoscopic surgery has

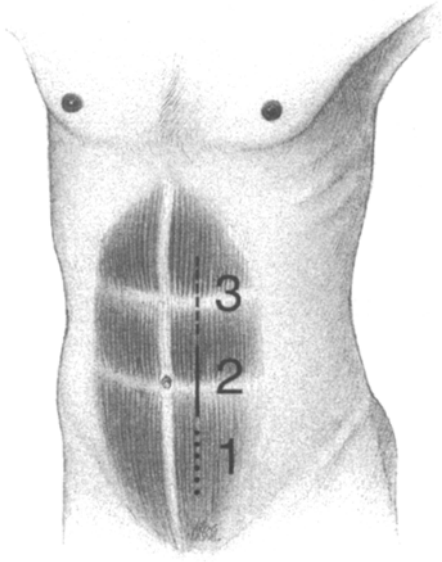
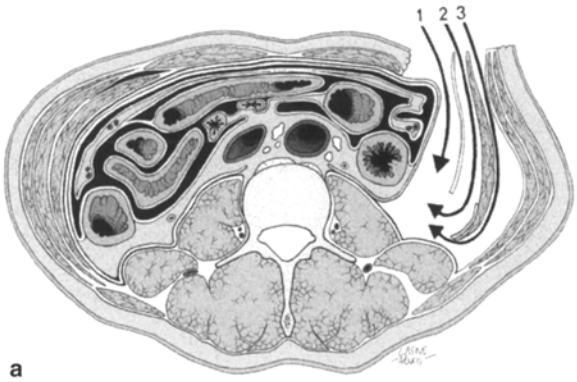


Fig. 1
Location of the cutaneous incisions according to the spinal levels to access: *1*, L4-L5 and L5-S1; *2*, L3-L4 and L2-L3; *3*, L1-L2 and T12-L1

led some authors to propose this technique for trans- or retroperitoneal graft procedures [6, 15, 16, 19, 20, 27, 28, 32, 44, 48, 49]. A conventional approach with videoscopic control has been described for the L4-L5 and L5-S1 levels [38]. Our experience is based on a very simple and short direct anterior approach without muscular division, with possible use of video-imaging techniques but without the need for special instruments. The objective for this approach (which is the same for all lumbar levels) is to be the least invasive but also the most reproducible procedure with minimal surgical risk in comparison with conventional techniques [14, 18, 35, 36, 43, 45]. The aim of this study was to specify some anatomic aspects useful for a safe technique and to evaluate the limitation of the spinal levels to be accessed and the possibilities of grafting and fixation. In the classic surgical literature, the potential technical difficulties are mainly focussed on the arterial lumbar system, kidney or ureter. This study emphasizes the surgical implications of the prevertebral venous anatomy, which must be familiar in order to successfully practice this «mini-invasive» surgery as venous hemostasis may be more problematic than lumbar arterial control.



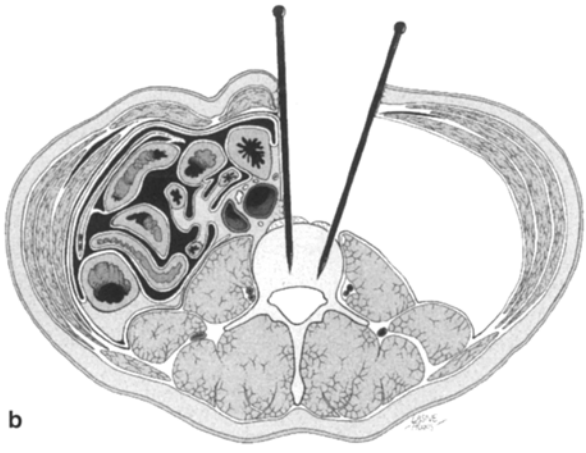


Fig. 2a, b
L4 level approach; **a** first stage: peritoneal dissection and access to psoas major m. 3 parietal approaches are possible; *1*, between the peritoneal fascia and the transversalis fascia; *2*, in front of the transversalis fascia; *3*, in front of the transversus abdominis m.; **b** second stage: mobilisation of the abdominal contents and insertion of Steinmann pins

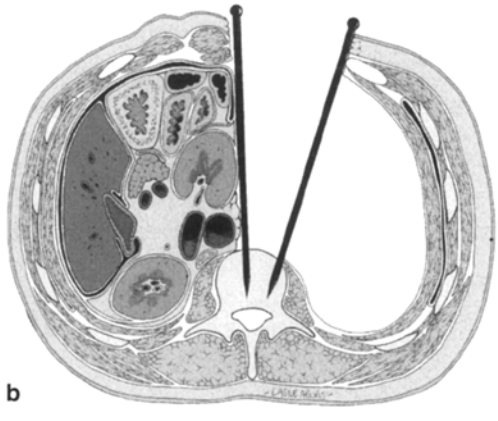


Fig. 3a, b
L2 level approach; **a** first stage: dissection up to the renal compartment; **b** second stage: mobilisation of kidney, the duodeno-pancreatic unit is indirectly moved to the right through its fascial attachment

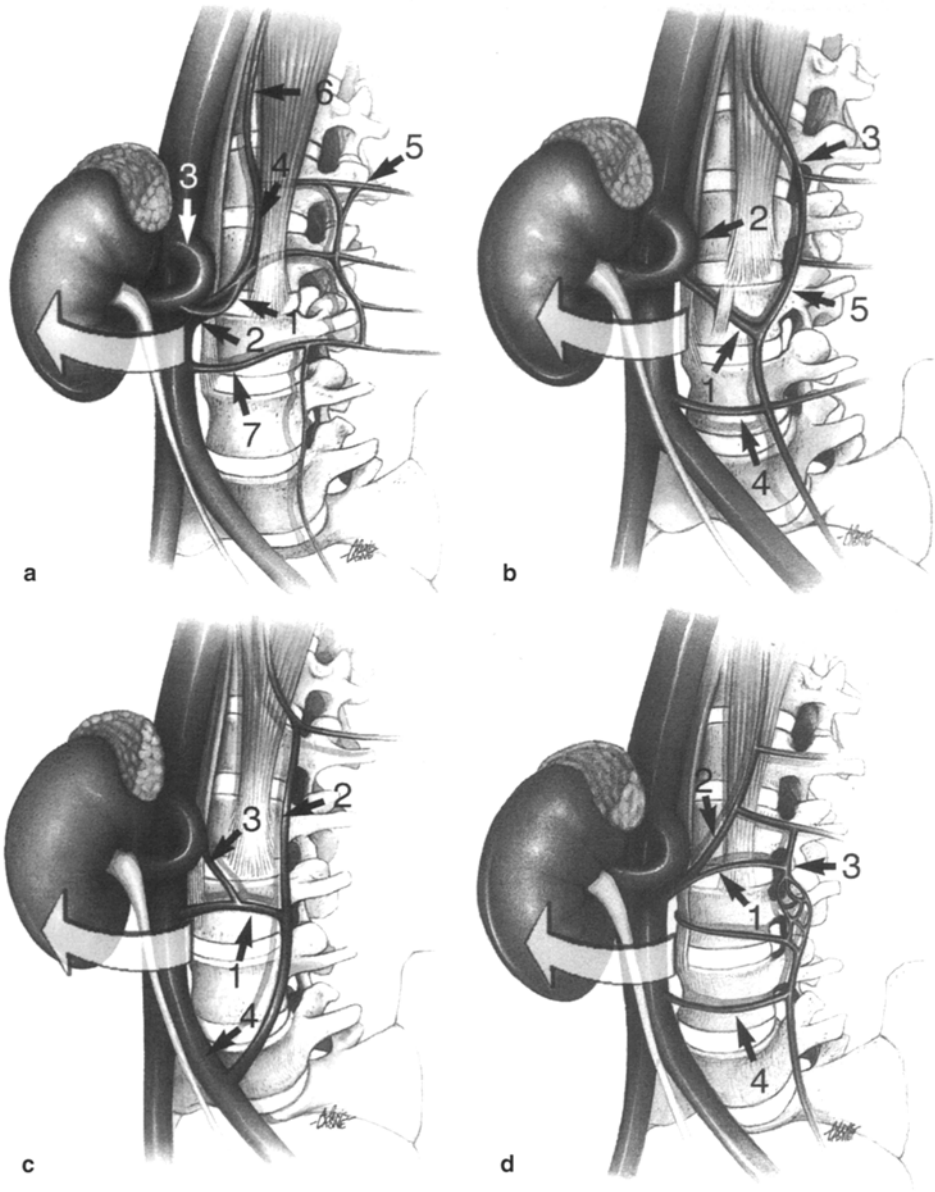


Fig. 4a-d
a Drawing from one of our dissections: typical pattern of reno-azygo-lumbar channel (*1*) between predominant L2 lumbar v. (*2*) and left renal v. (*3*). L2 lumbar v. is connected to the medial root of hemiazygos v. (*4*). Note convergence with lateral root of hemiazygos v. (*5*). Hemiazygos v. (*6*). L3 lumbar v. is present (*7*); **b** The most frequent arrangement is a «U-shaped» L2 lumbar v. (*1*) joining the left renal v. (*2*) (L2 type reno-azygo-lumbar channel) and lateral root of hemiazygos v. (*3*). Medial root is inconstant. L4 lumbar v. is present (*4*). Ascending lumbar v. (*5*); **c** Regression of L2 lumbar v. Predominance of L3 lumbar v. (*1*) joining ascending lumbar v. (*2*). Note the L3-type reno-azygo-lumbar channel (*3*) and junction between ascending lumbar v. and left common iliac v. (*4*). **d** Regression of L2 lumbar v. Predominance of L1 lumbar v. (*1*) with junction to medial root of hemiazygos system (*2*) and ascending lumbar v. (*3*). L3 lumbar v. is present (*4*)

Material and methods

Anatomic study

This was made in 25 cadavers, 3 of which were freshly injected with fluid and coloured latex. The cadavers were placed in intraoperative positions and the following points were studied when using this approach for anterior dissection: (a) peritoneal dissection procedure at the posterior sheath of the rectus abdominis m. and parietal fascia (transversalis fascia) [32] (b) evaluation of the dissection possibilities from T12 to S1. (c) evaluation of the prevertebral lumbar vascular pattern, especially the lumbar v., and of the accessibility of these vessels for hemostasis by using clips or diathermy.

Clinical study

This prospective study, performed from January 1995 to September 1997, evaluated the results in our first 42 patients (22 men and 20 women). The mean weight of the patients was 78 kg (range 58 to 120 kg), their mean age was 61.2 years (range 31 to 75 years) and the mean follow-up 1.5 years (range 4 months to 3 years). We excluded patients with significant aortic anomalies or thrombo-embolic history. They were operated on for grafting: intersomatic autologous corticocancellous grafts in the first 9 cases, carbon cages (SEM®) with autologous cancellous grafts in 30 patients, and 3 corporectomies with reconstructions using massive tricortical grafts fixed with screws. In 1 of the first 9 cases, a previously introduced metallic cage for posterior lumbar interbody fusion (PLIF) was removed through this approach and replaced with a corticocancellous graft. Twenty-nine patients had had previous intraperitoneal surgery and 2 patients previous retroperitoneal surgery. 3 patients had had a mesh for parietal reconstruction. 38 patients had had initial posterior fixation (pedicular screws and plates, Domino ® by Howmedica) (18 in a single stage, 20 in a previous procedure). In 4 patients, anterior carbon cages were used alone without associated posterior fixation . All operations were made on mechanical grounds and no intraspinal decompression was performed in this preliminary series.

Results

Operative procedure

Installation was in supine position on a table with lumbar support allowing easy modification of the lordosis in order to obtain the best lumbar curvature. Supports were placed against the right side of the trunk and the outer side of the leg. The surgeon was on the right side of the patient and the assistant on the left. The

vertical 4 to 5 cm long incision was slightly to the left of the midline (Fig. 1). Lateral radiologic check after installation gave precise location of the incision with regard to the different levels to be accessed. The lumbar support was then slightly lowered in order to facilitate the muscular approach and limit tension on the vessels. Immediately after opening the subcutaneous cellular tissue one could trace the sheath of the rectus abdominis m., which was then incised. The belly of the muscle had to be exposed to assess its lateral limit and the reflexion between its anterior and posterior sheaths. Incision of the posterior sheath gave access to the retroperitoneal region below the transversalis fascia (Figs. 2, 3).

Access to the retroperitoneal region was easier at the levels overlying the L4 vertebra because the peritoneum was stronger here. Below L4 level the peritoneum was weaker and the dissection could be delicate with the risk of peritoneal tearing, especially below the arcuate line as the posterior layer of the rectus compartment was made up only of the transversalis fascia. Progress was necessarily cautious using a swab to separate the peritoneum from the lateral abdominal wall, possibly starting with an inflatable balloon introduced in this area.

At the beginning of our study, we used a lateral balloon introduced through a left iliac incision or through the paramedian approach. Using alternate inflation and deflation, the peritoneal sack could be mobilised from left to right. Nevertheless, most of the time, the swab dissection was so easy that it was not necessary to use the balloon. Before reaching the retroperitoneal fat, the best and most reliable reference point was by direct palpation of the iliac crest and iliac fossa for lower levels or the deep aspects of the ribs for superior levels. A second and very efficient measure for avoiding involuntary opening of the peritoneal sac was by lengthening the dissection of the posterior rectus sheath. To open the compartment very laterally and access the transversalis fascia anteriorly, it was safer to incise this plane, almost touching the iliac crest, where the fascia gave direct access to the retroperitoneal fat.

Regarding previously operated patients or those presenting parietal weakness, it was more practical and quicker to cut the rectus sheath laterally in order to proceed between the transversus abdominis m. and the internal oblique m.; this approach gave access to the posterior portion of the transversus abdominis m. for detachment of its insertions on the transverse processes. The abdominal contents were then displaced with caution to the midline using a malleable laminar spreader, while simultaneously inclining the patient to the right side. This process was of great help in approaching the deep retroperitoneal area. The quadratus lumborum and psoas major mm. were used as guides and were easily identifiable, even in obese patients with a very fatty retroperitoneal space. Access to the perirenal fat was easy and proved an excellent indication point from which to go behind the kidney and displace it with the ureter, which remained adherent to the peritoneum. At the beginning of our study we performed intravenous urography on the operating table, but the constancy of the medial translation of the ureter now makes this procedure seem superfluous. The genital pedicle, testicular or ovarian, was retracted at the same time as the kidney.

Fig. 5
Degenerative L5-S1 discal pathology: previous posterior surgery with septic complications, anterior fusion with large carbon cage

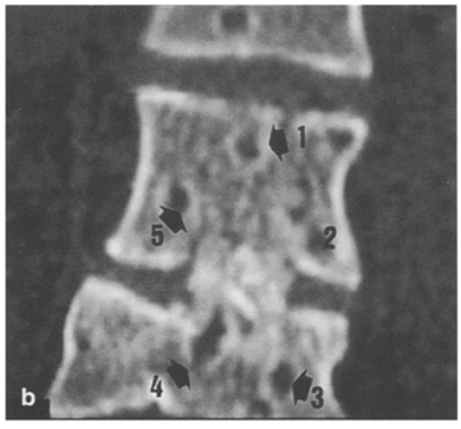


Fig. 6a, b
a Intraoperative view at L1-L2 level. Note the Steinmann pins exposing the operative field with protective valves (1/2/3/4); **b** Frontal CT-scan reconstruction with carbon cage at L1-L2 level, 7 months postoperatively. Note previous position of intraoperative Steinmann pins

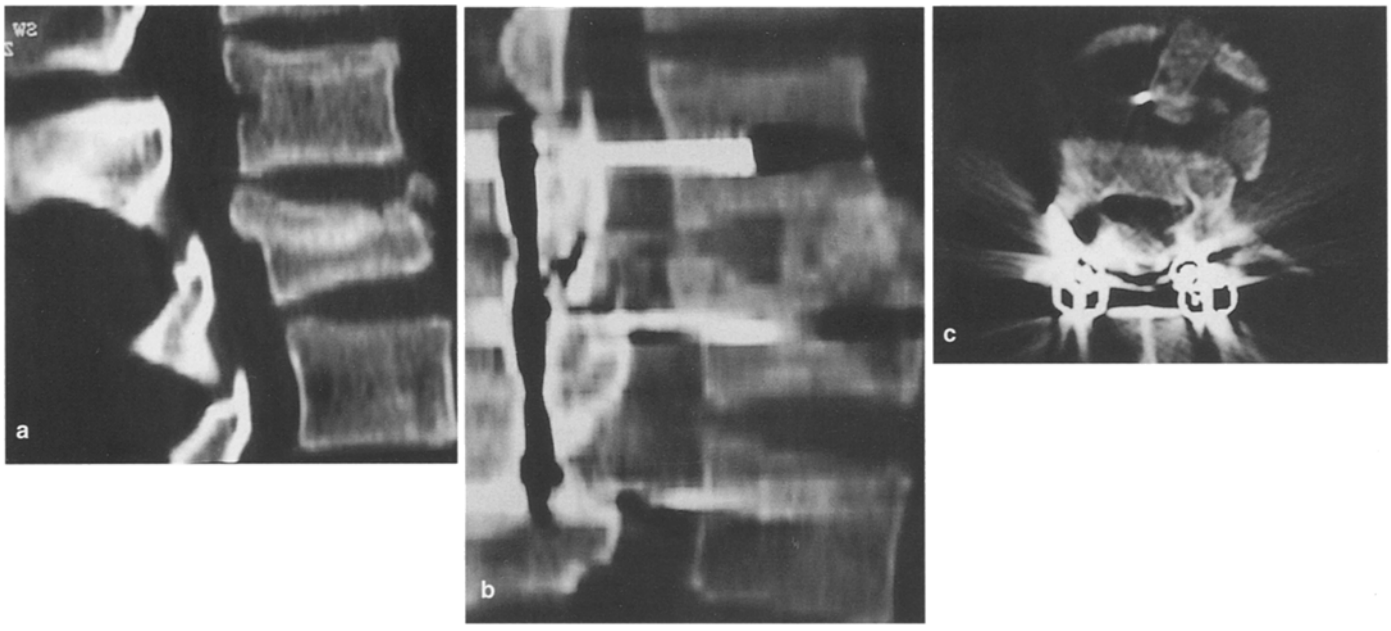


Fig. 7a-c
Pre- and postoperative views for two-stage L2-fracture treatment (without neurologic involvement); **a** preoperative sagittal CT scan reconstruction; **b** reduction and short posterior fixation with pedicular screws and plates: residual anterior bone loss needed a minimalized anterior retroperitoneal approach for grafting (indication on mechanical basis); **c** oblique position of carbon cage filled with spongious bone and surrounded with autologous spongious graft

At the L4-L5 level, two strategic choices were possible: the dissection might be started as for the overlying levels by using the plane of the renal compartment in order to strip the parietal peritoneum. The same incision then allowed following along L3 to L4 and L5 with the ureter still adherent to the peritoneal sac. for direct access to the left side of the L4-L5 disk, the dissection had to be made cautiously because the ureter did not adhere so firmly to the peritoneal plane at this level and could stay close to the psoas major m. and the iliac vessels. In 3 of our cadavers, the inferior pole of the kidney was the best starting-point for dissection of the parietal peritoneum and ureteral identification. Access to the spine was then easy by passing medial to the psoas major m. In some cases the iliac fascia was so strong and adherent to the prevertebral vascular space that it had to be opened anteriorly at the psoas major m. level in order to directly reach the prevertebral space. In most of the older patients with fragile soft tissues, simple stripping of the prevertebral fascia was sufficient. The medial laminar spreader was replaced by Steinmann pins introduced into the antero-lateral part of the vertebral bodies, but preventive hemostasis of the prevertebral plane was routinely performed. The obstructive transverse lumbar vessels were coagulated or clipped before introduction of the Steinmann pins. The lumbar aa. were easy to detect but the veins had to be carefully dissected because of important variations. The sympathetic trunk had to be avoided in its lateral situation. The pins might not only be placed pointing to the middle line, but also sometimes on the lateral side of the spine in order to relieve the assistant surgeon and eliminate the use of a lateral spreader. Placing these pins divergently gave a very good view of the spine.

The L4-L5 level was always reached using a left approach, but the dissection with the swab had to be careful to avoid injuring the left common iliac v. or the iliolumbar v. Depending on the chosen strategy for grafting, approach to the L5-S1 level might be medial (in our experience the approach could be made between the common iliac a. and v.), or lateral, to better protect the upper hypogastric plexus. For access to the T12-L1 level, Steinmann pins had to be placed ascendingly in order to retract the abdominal contents more effectively. In our study, the left crus of the diaphragm was easily identified, but it did not hinder the left antero-lateral approach to the spine as it could easily be sectioned after preventive hemostasis. At this stage a frontal and lateral radiographic check was performed before starting discal excision or corporectomy. The lumbar support was fixed in its definitive position. An endoscopic video system could be introduced through this associated lateral incision or in the main incision in order to obtain better vision and to illuminate the surgical field. Through a 5 cm skin incision, this approach provided an appropriate opening to perform discal excision at 3 levels or one corporeal resection and to introduce adequate intersomatic cages or grafts. Osteosynthesis was also possible.

Anatomic aspects of left ascending lumbar v. and lumbar vv. (Fig. 4)

The most common distribution was based on the predominance of lumbar v. at L2 and L4. The L1 lumbar v. was often absent and replaced by a larger internal root of the azygos system (11/25 cases). The L3 lumbar v. was frequently atrophic or nonexistant (16/25 cases). This area was an intermediate junctional zone between the ascending azygos flow and the descending iliac flow. The L2 lumbar v. was common (20/25 cases) and a reno-azygos lumbar channel was found in

17/25 cadavers. This imposes gradual mobilisation of the peritoneal cavity, renal block and left renal v. in order to avoid excessive traction on the prevertebral venous plane.

1 - The most frequent case was a large lumbar v. at L2 having a characteristic U-shaped configuration. This L2 lumbar v. joined the left renal v. and the lateral root of the hemiazygos v., forming an «L2 type» reno-azygo-lumbar channel (12/25 cases).

2 - In some cadavers, a large L2 lumbar v. joined the lateral root of the hemiazygos system (8/25 cases). An uneven inconstant could be found between the left renal v. and L2 lumbar v. forming a kind of reno-azygo-lumbar channel (3/8 cases).

3 - Regression of the L2 lumbar v. could be almost complete, to the profit of the L1 lumbar v., which formed the medial root of the azygos system (3/25 cases); in 2 of these 3 cases, a reno-azygo-lumbar channel of «L1 type» was encountered with connection to the posterior face of the left renal v.

4 - Regression of the L2 lumbar v. to the benefit of the L3 lumbar v., which formed a common vessel with the medial root of the azygos system. It reached the inferior vena cava at the level of the L2-L3 disk (2/25 cases).

Anatomic aspects of the superior veins

The left superior intrapsoas venous system was closely related to the azygos system. 3 roots were observed:

1 - a lateral root coming from the junction of the ascending lumbar v. and the subcostal v. It remained remote from the anterior approach area but an important root could be the L2 lumbar v. or a reno-azygo-lumbar channel coming from the left renal v. This pattern was observed in 7/25 cases ;

2 - a medial root coming from the posterolateral side of the infrarenal inferior vena cava in most of the cases, either separately or through a common vessel with the L2 lumbar v., or through a common root with a reno-azygo-lumbar channel (coming from the left renal v.). This root was inconstant (8/25 cases) and could be easily coagulated for hemostasis ;

3 - a middle root which was very small and inconstant (3/25 cases), arising from the posterior face of the infrarenal vena cava at the L2 level, with a prevertebral and retroaortic course through the diaphragm to join the medial root of the left hemiazygos system.

Anatomic aspects of the inferior intrapsoas plexus: ascending lumbar v. and iliolumbar v.

The iliolumbar v. and ascending lumbar v. converged in the common iliac v. in the vast majority of cases (24/25 cases) in our study. At this level, they had similar diameters (3 to 5 mm) and were separated by the lumbosacral trunk (the ascending lumbar v. passing in front and medially and the iliolumbar v. behind and laterally).

Clinical study

The mean operation time for lumbar spine access was 15 minutes (range 10-25 minutes) at any level. No additional bleeding was noted compared with our previous technique of lateral approach. We did not observe any complications: no vascular damage or hemorrhagic complications, no ureteral injuries, no pancreatic reaction, retroperitoneal fibrosis or muscular complications. 3 patients suffered from a transitory weakness of the psoas major m., due to excessive muscular retraction, which disappeared within 2 weeks. A local peritoneal tear was observed in 8 of our first 19 cases during the initial separation of the peritoneal fascia and the posterior rectus sheath; it was immediately sutured in 3 cases and left untreated without any illconsequences in 5 cases (posterolateral tear). In our later 23 cases we observed no peritoneal tears. 1 case of subcutaneous infection in an L4-L5 approach was treated with local debridement. It was observed in one of our first cases because the incision was too medial towards the umbilicus, resulting in skin malunion. No retrograde ejaculation was noticed in our 22 male patients. No pseudarthrosis or graft migration was observed and the period for fusion was equivalent to the lateral approach (assessment of bone-bridging and fusion on standard X-rays and CT-scans) (Figs. 5, 6). We performed 4 cases with anterior grafting alone. To date no complications have occured and all cages have fused , but further evaluation on more cases is necessary.

Discussion

Anatomic basis of this approach

Vascular aspects

Knowledge of the anatomic intricacies of the retroperitoneal vessels and the different planes of this region is important because of potential damage to the ureter or vascular structures [5, 23, 41, 46]. Careful dissection must be performed because of possible prevertebral lumbar venous dilatation and inferior vena caval compression. Anomalies of the retroperitoneal venous network have been previously investigated [13] regarding some acute or chronic postsurgical spinal cord complications [1, 14]. Analysis of the CT scans or horizontal and sagittal MRI images must always study the «left vertebral angle» in order to determine the possible presence of aortic calcifications, malformations or even an abdominal aortic aneurysm, which is an absolute contraindication to this approach.

Retroperitoneal dissection can begin very low, starting at the iliac portion of the retro-peritoneum after initial iliac approach; it allows the surgeon to follow the vascular axes upwards without any fascia blocking the way [3, 5]. Identification of the quadratus lumborum and psoas major mm. is always easy, remaining covered by the parietal fascia. The use of a lateral balloon does not add to security in separating the ureter or the genital pedicle and these elements were never an obstacle as they remained attached to the peritoneum. Regarding this anterior approach, the ascending lumbar v. is more lateral.

Gillot [24] described particular features of the lumbar venous system. The lateral vertebral venous plexus was never identified as a rectilinear vessel, classically called the ascending lumbar v. On the contrary, it was an irregular, plexiform branch with very different segmental diameters. The bridging zone between the ascending azygos and descending iliac

flows was frequently atrophic or interrupted at the middle part of the lumbar spine. The origin of the hemiazygos v. was the junctional point between the internal vertebral and superior lumbar plexuses, inferior vena cava and left renal v. The L2 lumbar root was constant and frequently made up the lateral root of the hemiazygos v. through the classic reno-azygo-lumbar channel. This was sometimes found at the L1 or L3 level. Our observations, focussed on the surgical aspects, were almost the same, especially regarding Gillot's concept of the L2 v. and reno-azygo-lumbar channel. We rarely observed the «modal description» [24], according to which the inferior vena cava and a straight ascending lumbar v. are attached to one another by lumbar v. at every level.Three different zones could be distinguished for the relations with the lumbar plexus:

1: In the lower zone, around L4 and L5, the ascending lumbar v. passed anterior to the L4 and L5 roots medially and behind the obturator and femoral nn. The iliolumbar vessels were located in a more posterior plan than the L4 root.

2: In the intermediate zone, around L3, the ascending lumbar v. became posterior to the roots of the lumbar plexus. Different findings were possible: it might pass either under and then behind the L3 root, or in front and over it, or may split to form a venous bypass on either side of the L3 root.

3: In the upper zone, around L1 and L2, the ascending lumbar v. traveled behind the nerve roots. It was crossed by the abdominal cutaneous and genitofemoral n. In its diaphragmatic portion, the ascending lumbar v. was always behind the body of the psoas major m. originating from T12; it passes under the medial arcuate lig.

The ascending lumbar v. represented the axis of the intra-psoas venous plexus, with three different roots:

– ascending to the external root of the hemiazygos v.,

– descending to the common iliac v. between its ending and the iliolumbar v. anastomosis

– theoretical transverse roots at every level to the inferior vena cava through the lumbar v. under the psoas major m. attachments to the vertebral bodies.

Knowledge of the superior lumbar v. variations and reno-azygo-lumbar channel is essential. Some surgeons perform a single thoracoscopic approach to the thoracolumbar junction: A venous complication is always possible with this approach and may be difficult to manage. Routine complementary monitoring of these veins under the diaphragm should be performed as well as lymph node check for safety. Significant venous anomalies of the inferior vena cava and left renal v. were rare (2% of cases). Left retroaortic renal v. was the most frequent anomaly, but did not have any consequences for our approach [12]. We encountered this variation in two patients. The CT scan allows their detection with a high degree of certainty [4, 7, 10, 22, 25]. Stenosis of the left iliac v. resulted in rerouting of drainage to the vertebral plexus via the ascending lumbar and presacral v. without consequences for our approach. Compression of the left renal v. resulted in dilatation of the lumbar v. which drains the whole or part of the renal output into the internal vertebral plexus [30]. Routine analysis of the preoperative CT-scan or MRI images allowed detection of such an anomaly, which may result in intraoperative problems of control or hemostasis; preoperative phlebography may be useful [4].A reno-caval arch, also known as the reno-iliac arch (depending on the location of the inferior merger), led from the inferior face of the left renal v. to the lateral, infra-renal face of the inferior vena cava or the common iliac v. This variation is important because it resembles an incomplete left inferior vena cava of small diameter. This arch may support the lateral root of the hemiazygos v., most often with a common origin with the L3 lumbar v. We encountered this situation in one of our dissections. This variation was very easily identified and the venous channel could be simply clipped through the anterior approach.

Arthornthurasook [2] distinguished two different merger configurations in the inferior portion of the intra-psoas plexus:

– two separate vessels for the ascending lumbar v. and the iliolumbar v. (57% of the cases).

– one single vessel (43% of cases) formed by the union of the ascending lumbar v. and 1 to 3 ilio-lumbar v.

One very special configuration is the merging of 3 distinct branches: ascending lumbar v. and 2 iliolumbar v. Knowledge of these variations is important for the anterolateral approach to the L4 L5 and L5 S1 disks and to ensure safe hemostasis. These veins did not cause any problems in our dissections, nor in any of our operations, because they are more lateral. Nevertheless, if one wants to mobilize the common iliac v. for simultaneous L4-L5 and L5-S1 approach, intraoperative control of these vessels must be correctly performed.

Lymph nodes

We did not encounter any chylous injury following this anterior approach. In one case an asymptomatic collection was observed on routine postoperative CT-scan after L2-L3 and L3-L4 procedures in a 120 kg patient, but without any information on its nature. Cases of retrochyloperitoneum following anterior spinal arthrodesis have been reported [8, 9, 17, 42]. We recommend that no lymph node biopsy should be performed and that, if there is the slightest suspicion of a lymphatic vessel lesion, ligature or clipping must be done [11]. The cisterna chyli is assumed to be usually located between T11 and L2 [39, 40]; thus it will not be injured during the dissection required for grafting. Jdanov [29] states that this initial cisterna exists only in 50% of cases. In 35% of cases the origin of the thoracic duct is between L1 or L2 in the retroaortic plane and in 65% of the cases the origin is between T11 and T12.

Comparison with other retroperitoneal approach techniques

Onimus [38] described video-assisted extraperitoneal access to the lower lumbar spine through an anterior approach. Such a retroperitoneal approach using the midline does not result in excessive muscular lesioning or digestive complications. He mentioned the relative difficulty of peritoneal dissection in the lower lumbar spine but did not give any indications for avoiding peritoneal tears. He used a

special laminar spreader applied against 2 Steinmann pins. He gave no further details about access possibilities to the higher lumbar spine. In our approach, we used 3 different strategies for peritoneal stripping. In cases of easy dissection without previous surgery, the approach between the peritoneum and transversalis fascia may be chosen. In cases with previous surgery or a weak abdominal wall, one can choose to pass in front of the transversal fascia or between the transversus abdominis and internal oblique mm. We did not vary any of our instruments; long and narrow laminar spreaders are only necessary when retracting the peritoneal cavity before Steinmann pinp placement. The use of these pins was very rewarding because, by moving them successively along the spine, they allowed us to apply gradually increasing counterpressure to the axial vessels and to perform very extensive approaches up to T12. The thin layer of the retroperitoneal compartment at this level imposes the use of very flat and nonaggressive osteosynthesis material if complementary fixation is needed.

Mayer [34] described a transmuscular retroperitoneal anterolateral approach necessitating a sophisticated spreader system. Besides the common risk of injuring the iliohypogastric and ilioinguinal nn. during the parietal approach, the lymphatic chain and ascending lumbar v. must be ligated. This approach is limited and does not exclude the necessity for a transperitoneal approach for the L5-S1 level with the risk of injuring the upper hypogastric plexus [47]. The superior limit of this approach is L2. The patient has to be placed in extreme lateral flexion, which may result in graft malpositioning with fusion in the wrong position. Our direct anterior access does not need such an asymmetric opening of the disk space. Fraser [21] described a modified muscle-splitting retroperitoneal approach to the lumbosacral spine. This approach was only used for the last three levels from L3 to S1. The L3-L4, L4-L5 and L5-S1 were reached using two different approaches. The skin incision was much longer (10 to 20 cm) and muscle sectioning was necessary. He stated that the left common iliac v. was often tethered laterally by a segmental v., referred to as the iliolumbar or ascending lumbar v. He did not mention any venous complications. Nevertheless, he stressed that a vein can be injured by the inferior spreader and this necessitates extreme care from the surgical assistant. He also recommended a medial approach for L5-S1, with potential lesional risk to the upper hypogastric plexus; nevertheless, he observed no retrograde ejaculation in his series.

At L3-L4 and L4-L5 levels, the sympathic trunk is mobilised laterally. Our medial approach did not necessitate any notable dissection of the sympathetic trunk. In our series, we observed only one increase in perfusion of the left lower limb, in a posttraumatic case with disruption of the sympathetic trunk due to the lesion. At L5-S1 level, the incision is guided by the radiologic projection of the peroperative X-rays (vertical or Pfannenstiel type). The right-sided approach is theoretically easier : the right common iliac a. protects the vein; the ureter is further away and slightly easier to mobilize with the peritoneum. Nevertheless, most of our L5-S1 operations were performed through left-sided approaches (only 2 right anterior approaches).

Other surgeons have promoted lumboscopy [32, 37]. This technique requires very sophisticated material and longer operating times. Morbidity is low but complication rates range from 16.7% to 29.4% and may be attributable to the learning curve and small number of patients [36]. The simplicity of our paramedian anterior retroperitoneal approach and the rapidity of its performance seem to seriously outweigh the relative value of several punctiform incisions. In case of vascular complications, a wide, safe and immediate exposure is possible. Whatever discal excision technique is used, anterior grafting must provide large vertebral contact surfaces, sufficient stability and complete preparation of the grafting site. Technical limits of endoscopic approaches may induce insufficient discal excisions and grafting, with potential secondary mechanical complications. That is the reason why we use video-imaging techniques only as a complementary tool for local check and better illumination.

In our experience, anterior grafting with this approach did not usually dispense with an initial posterior approach. Posterior implants are often necessary to restore normal lumbar curvature: the graft only acts as complementary stabilisation after first correcting the initial deformity. We used anterior grafting with cages alone in 4 cases but further evaluation in more cases is necessary. We used only one graft, or one cage with an autologous cancellous graft, surrounded by autologous cancellous bone. In our experience, the use of two cages was not necessary; furthermore, some authors point out that using 2 grafts may lead to pseudarthrosis of one [26], because of asymmetric loading. In our experience, lateral visualisation of the L4-L5 and L5-S1 disks and protection of the upper hypogastric plexus, which is not dissected [47], impose in some cases oblique application of the tricortical graft or carbon cage at these levels. It never induced any mechanical complication and no case of pseudarthrosis has been observed so far.

Conclusion

This minimalized anterior extraoperitoneal approach (MAEA) is a useful alternative to access the entire lumbar spine. It avoids the parietal complications of the classic lateral approaches and allows very extensive vertebral access through the same short 5 cm incision. Even with the new techniques for lateral mini-approaches, accessing the lumbosacral junction remains difficult. Costal osteotomy or resection is not necessary at the thoracolumbar level T12-L1. There is no risk of injuring the upper hypogastric nerve plexus at the lumbosacral junction L5-S1, since the approach is anterior and discal excision and grafting are performed obliquely. The classic descriptions of anterior approach techniques state the potential risks inherent to the ureter and the lumbar aa. This study shows above all the importance of anatomic knowledge of the venous retroperitoneal system in order to use this technique with minimal risk. It benefits from a very brief assimilation of the technical details without the necessity for sophisticated and expensive instruments. This technique can be very useful in degenerative disorders as well as traumatology. In degenerative lesions, the application field is very large but is mainly focussed on the debate regarding

PLIF (with its potential neurologic complications or supplementary bleeding) and this type of ALIF (anterior lumbar interbody fusion). In the near future, this approach may also be considered for discal prosthesis introduction and fixation.

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