EXPERIMENTAL LAPAROSCOPIC AORTOBIFEMORAL BYPASS FOR OCCLUSIVE AORTOILIAC DISEASE

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OBJECTIVE: To describe a totally laparoscopic technique for aortobifemoral bypass to treat aortoiliac atherosclerotic occlusive disease.

DESIGN: A feasibility study.

SETTING: A university teaching hospital.

SUBJECTS: Six piglets weighing between 70 and 80 kg were submitted to a totally laparoscopic retroperitoneal aortobifemoral bypass, performed through six trocar sites, with abdominal suspension and a gasless technique. No minilaparotomy was performed. After systemic heparinization, the infrainguinal aorta was cross-clamped and the aortic bifurcation stapled. An end-to-end aorto-prosthetic anastomosis was performed. Retroperitoneal tunnels were created to allow each limb of the graft to join its corresponding femoral artery by a conventional anastomosis.

INTERVENTION: Totally laparoscopic aortobifemoral bypass.

MAIN OUTCOME MEASURES: Duration of the procedure, intraoperative blood loss and operative complications, bleeding in the immediate postoperative period. Evaluation of the aortic anastomosis at autopsy.

RESULTS: All aortobifemoral bypasses were completed in less than 4 hours. Intraoperative blood loss did not exceed 250 mL. No intraoperative complication was encountered except occasional bleeding at the aortic anastomosis upon releasing the arterial clamp. This was controlled with a collagen sponge (three cases) or extra stitches (two cases). The animals were observed for 15 minutes before sacrifice. Autopsy revealed a normal aortic anastomosis in all cases and a normal progression of the limbs of the graft under the ureters in the retroperitoneal tunnels.

CONCLUSIONS: This animal model demonstrates the feasibility of the aortobifemoral bypass through a laparoscopic approach. The retroperitoneal anatomy of the piglet is similar to that of man. Aortic surgery can be conducted as for the standard technique. We used a similar approach to perform the first human, totally laparoscopic aortobifemoral bypass with an end-to-end anastomosis.

OBJECTIF : Décrire une technique totalement laparoscopique permettant d’effectuer un pontage aortobifémoral comme traitement de la maladie athéromateuse occlusive aorto-iliaque.

CONCEPTION : Une étude de faisabilité.

CONTEXTE : Un hôpital d’enseignement universitaire.

SUJETS : Six porcelets pesant de 70 à 80 kg furent soumis à un pontage aortobifémoral effectué de façon totalement laparoscopique par voie rétropéritonéale. Un appareil de suspension abdominale et une technique ne nécessitant pas d’insufflation de gaz furent utilisés. Aucune minilaparotomie ne fut nécessaire. La chirurgie fut effectuée au moyen d’une instrumentation laparoscopique insérée à travers six sites de trocar. Après héparinisation systémique, l’aorte abdominale fut clampée et la bifurcation aortique clippée. Une anastomose aorto-prothétique termino-terminale fut effectuée. Les tunnels rétropéritonéaux furent créés...
de façon à permettre à chacun des membres de la prothèse d’être acheminé vers sa région fémorale respective. Une anastomose conventionnelle fut effectuée au niveau des artères fémorales.

**Intervention** : Pontage aortobifémoral effectué totalement par laparoscopie.

**Principales mesures de résultats** : Durée de l’intervention, pertes sanguines et complications per-opératoire, saignement durant la période post-opératoire immédiate et évaluation post-mortem de l’anastomose aortique.

**Résultats** : Tous les pontages aortobifémoraux furent effectués en moins de 4 heures chacun. La petite sanguine per-opératoire fut inférieure à 250 mL. Aucune complication per-opératoire ne fut notée sauf pour la survenue d’épisodes de saignement lors du déclamping aortique. Ce type de saignement fut contrôlé par application d’une éponge de collagène (trois cas) ou de sutures supplémentaires (deux cas). Les animaux furent observés pendant 15 minutes avant sacrifice. L’autopsie révélée à ce moment une anastomose aortique normale dans tous les cas et un cheminement normal des membres de la prothèse à la fois par rapport aux uretères et dans leur trajet rétropéritonéal.

**Conclusions** : Ce modèle animal démontre la faisabilité du pontage aortobifémoral utilisant une technique laparoscopique. L’anatomie rétropéritonéale du porcelet est similaire à celle de l’humain. La chirurgie aortique est effectuée selon les principes de la technique standard. Nous avons utilisé une approche similaire pour effectuer, chez l’humain, le premier pontage totalement laparoscopique au moyen d’une anastomose termino-terminale.

**DION ET AL.**

A few years ago, we described a technique for laparoscopy-assisted aortic surgery in humans. Further investigation led to a different approach to the abdominal aorta for totally laparoscopic aortobifemoral bypass. The purpose of the present article is to demonstrate a technique, developed in piglets, that allowed the first totally laparoscopic aortobifemoral bypass with an end-to-end aortic anastomosis in a human with occlusive aortic disease.

**Materials and Methods**

The animal experiments were approved by the institutional Animal Care Committee and were conducted according to the guidelines of the Canadian Council for Animal Care. Six female piglets (average age 6 months and weight range from 75 to 80 kg) were premedicated with atropine sulfate (Astra Pharma, Mississauga, Ont.), 1.2 mg intramuscularly. They were anesthetized with pentobarbital sodium (25 to 35 mg/kg). Anesthesia was maintained with a continuous intravenous infusion of pentobarbital sodium (5 to 10 mg/kg per hour). Through an endotracheal tube, they were artificially ventilated by means of a volumetric Bird respirator at a tidal volume of 7 to 8 mL/kg, a frequency of 10 to 12 breaths/min and an air mixture containing 25% oxygen. The ventilator was adjusted to maintain the PaO$_2$ between 95 and 135 mm Hg and the PCO$_2$ less than 40 mm Hg. An arterial line was inserted into the right carotid artery. The right internal jugular vein was dissected to allow insertion of a catheter for infusion of crystalloids or withdrawal of blood samples.

**Surgical technique**

Our technique of laparoscopic retroperitoneal exposure of the aorta has been described elsewhere. Briefly, six trocars were used to insert various laparoscopic instruments and the graft. The retroperitoneal cavity was maintained by the use of an abdominal wall lifting device (Laparolift; Origin Medical Systems, Menlo Park, Calif.).

Our technique of laparoscopic aortobifemoral bypass for aortoiliac occlusive disease has been modified as follows: Laparoscopic scissors are used to dissect the infrarenal aorta and both external iliac arteries. The inferior mesenteric artery is clipped and severed. The lumbar arteries near the inferior mesenteric artery are dissected, clipped and divided (Fig. 1). Then, the aorta, at a point slightly cephalad to the inferior mesenteric artery, is carefully dissected circumferentially with the use of an Endo Maxi Retract (Auto Suture Company, Norwalk, Conn.) (Fig. 2). Prior ligation of the lumbar arteries at this level facilitates the manoeuvre. The vascular graft (Hemashield; Meadox Medicals, Oakland, NJ) is introduced through one trocar port and fashioned in such a way (6 mm × 6 mm) that the prosthesis would be of the same calibre as the piglet aorta, which averages 6 mm. Incision in the femoral regions allows exposure of the common femoral arteries. The retroperitoneal tunnels are created by dissecting the proximal iliac arteries laparoscopically, then inserting a large Crawford clamp from the femoral region. Its proximal progression is followed under laparoscopic control. Each limb of the graft is introduced into its respective retroperitoneal tunnel and pulled into the femoral region. Care is taken to ensure proper placement of the ureters above the limbs of the graft. After systemic heparinization (100 IU/kg), the aorta distal to the left renal artery is cross-clamped with a laparoscopic vascular clamp (Laborie Surgical, Brossard, Quebec). A laparoscopic vascular TA 30 stapler (Auto Suture Company) is used.
to staple the distal aorta, where the Endo Maxi Retract instrument is positioned and protects the inferior vena cava (Fig. 3). The aorta is transected with laparoscopic scissors distal to the aortic cross-clamp (Fig. 4). The graft is then sutured end-to-end to the proximal aortic stump with running 4-0 Prolene (Fig. 5). After the anastomosis has been tested for leaks, the aorta is again cross-clamped. The limbs of the graft are placed under appropriate tension and the femoral anastomoses are performed with 5-0 Prolene (Fig. 6). The animals are observed for 15 minutes after completion of the procedure and are then killed.

RESULTS

All animals survived the procedure. Intraoperative blood loss did not exceed 250 mL and was principally due to the flushing techniques used before definitive unclamping. Extra sutures were applied to the aortic anastomosis in two cases because of blood leakage. A collagen sponge sufficed to control oozing in three cases. No bleeding occurred at the site of aortic stapling. No procedure took longer than 4 hours.

At autopsy, a small amount of blood was found in the retroperitoneum in most animals, as would be encountered in any surgery of this kind. No major bleeding source was noted. In all cases, the ureters were in an appropriate position where they crossed the limbs of the graft. The proximal anastomoses were transected and found to be adequately sewn.
DISCUSSION

We previously described a technique of laparoscopy-assisted aortobifemoral bypass that has since been performed successfully by others. All agree that the potential benefits afforded by the laparoscopic approach in other fields of surgery could alter positively the postoperative course of patients who undergo aortoiliac vascular procedures.

Because of difficulties we encountered with the transabdominal approach, such as inefficient bowel retraction and the need to close the retroperitoneum at the end of the procedure, we prefer the retroperitoneal route for the safety of laparoscopic aortoiliac surgery. The use of the peritoneum as a barrier against intrusion of intra-abdominal organs into the surgical field eases the procedure. The large piglet is a reproducible and excellent model because its abdominal wall and retroperitoneum are similar to those of man and because the same instrumentation can be used in humans.

We believe that an abdominal wall lifting device is essential for this procedure. It maintains a permanent cavity, which does not threaten to collapse when prolonged suctioning is necessary. We showed in the laboratory that the procedure can be performed solely under pneumoperitoneum, but the lifting device adds safety if bleeding occurs. We are assessing the value of combining a retropneumoperitoneum with the lifting device. We recently demonstrated that maintenance of euvolemia could decrease appreciably the danger of carbon dioxide pulmonary embolism, which might occur after laceration of a large vein like the vena cava (or a lumbar vein).

The actual technique of laparoscopic aortobifemoral bypass used in this model resembles the conventional open retroperitoneal technique with minor modifications. Ligation of the inferior mesenteric artery allows for the creation of a larger retroperitoneal cavity. Ligation of a pair of lumbar arteries makes for easy dissection of the distal aorta and the passage of the laparoscopic vascular TA-30 stapler. We elected to secure the graft in place for two reasons: first, it shortens cross-clamping time without compromising the ability to apply extra stitches at the back of the anastomosis, because no tension is applied on the limbs of the graft; second, it allows the graft to sit in a good position for the performance of the aortic anastomosis. The level of anticoagulation obtained is similar to that encountered in humans. We have now performed 22 aortobifemoral bypasses in animals and have found that the ureters are not endangered. The left ureter is dissected from the retroperitoneum and positioned on the left psoas muscle at the beginning of the procedure.

This animal model does not allow performance of the anastomosis in an atherosclerotic aorta. Our initial experience in man confirms that an atheromatous aorta does not pose a problem to a laparoscopic anastomosis, which is performed under the magnification afforded by a videoscanner. A calcified aorta would necessitate endarterectomy as in open surgery.

In summary, this animal model demonstrates the feasibility of a totally laparoscopic aortobifemoral bypass for aortoiliac occlusive disease. A similar technique allowed us to perform the first human totally laparoscopic aortobifemoral bypass for aortoiliac disease using an end-to-end aortic anastomosis.
References

Addendum
As of August 1996, two of the authors (Y.-M.D. and C.R.G.) have successfully performed four more totally laparoscopic aortobifemoral bypasses and two totally laparoscopic iliofemoral bypasses in humans. The abdominal wall lifting device was judged unnecessary, and the procedures were done with the use of carbon dioxide pneumoperitoneum. The retroperitoneal approach has been modified to facilitate the procedure.

Correction
There was an error in abstract number 707 on page A30 of the abstract supplement to the August 1996 issue of the Journal: the name of Dr. D.C. Taylor was omitted from the list of authors. The information on the title, authors and centre for abstract 707 should appear as follows: PROGRESS IN ABDOMINAL AORTIC ANEURYSM SURGERY: FOUR DECAD E S OF EXPERIENCE AT A TEACHING CENTRE. J.C. Chen, H.D. Hildebrand, A.J. Salvian, D.C. Taylor, Y.N. Hsiang. Department of Surgery, Vancouver Hospital and Health Sciences Centre, University of British Columbia, Vancouver, BC. We apologize to Dr. Taylor and his co-authors for this error.