

Traitement endoluminal des anévrysmes aortiques complexes englobant des branches viscérales majeures par fenestration laser in situ *



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Technique développée par le **DR DOMINIQUE FABRE
Hôpital Marie **LANNELONGUE**. Le Plessis-Robinson*

Le traitement endo-vasculaire des anévrysmes de l'aorte abdominale et thoracique par stent graft est devenu une alternative reconnue à la chirurgie directe depuis une dizaine d'années (JO 2008)



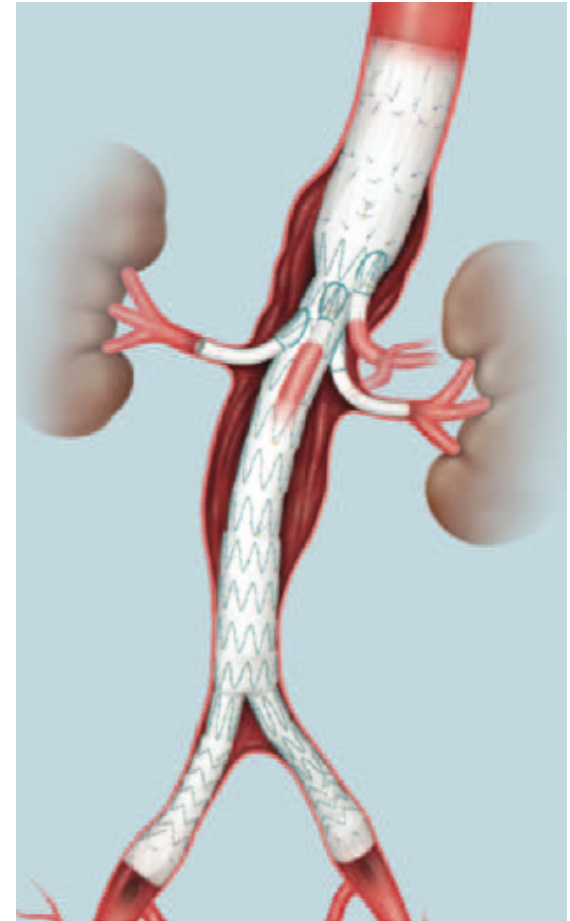
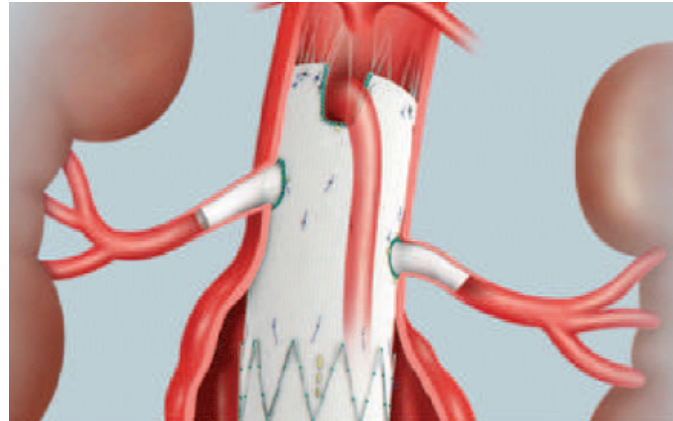
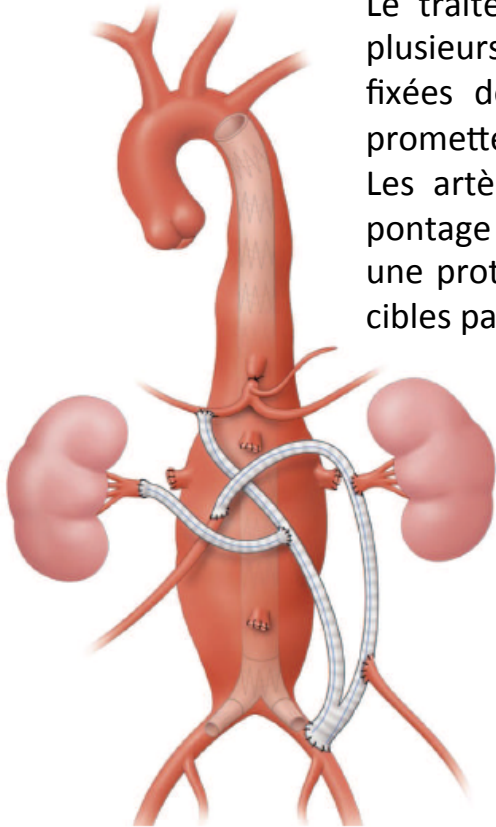
- ✓ Moins de mortalité et de morbidité, particulièrement chez les patients à haut risque.
trois études randomisées (EVAR 1, DREAM et OVER) ont montré une réduction significative de la mortalité intra-hospitalière et des complications postopératoires par EVAR versus chirurgie ouverte
- ✓ Séjours hospitaliers plus courts
- ✓ Récupération plus rapide
- ✓ Moindre coût
- ✓ Offre une solution efficace à des patients trop fragiles jusque là considérés comme inopérables

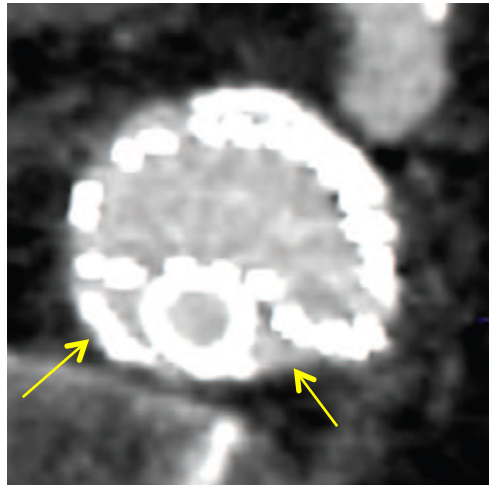
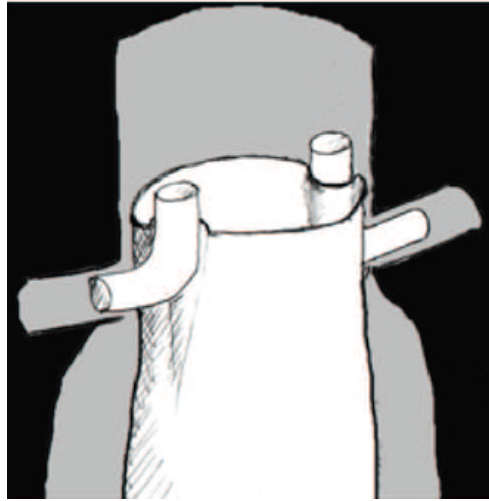
Cependant, les anévrysmes englobant des artères viscérales majeures demeurent délicats à traiter ...

la morbi-mortalité de la chirurgie ouverte est rédhibitoire

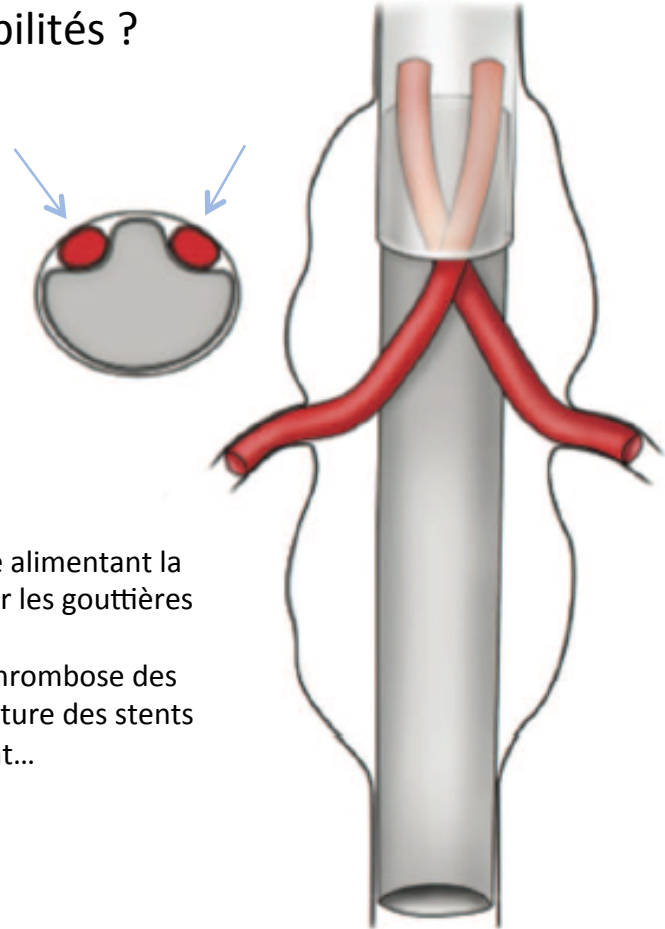
Le traitement par voie endoluminale utilisant un ou plusieurs stents auto-expansibles sur lesquels sont fixées des prothèses de Dacron est une alternative prometteuse.

Les artères viscérales doivent être perfusées par un pontage ou des fenêtres ou branches aménagées dans une prothèse faite sur mesure, raccordées aux artères cibles par des stents couverts.





Quelles possibilités ?
Cheminées ?
Sandwich ?



Risque majeur de fuite alimentant la poche anévrysmale par les gouttières

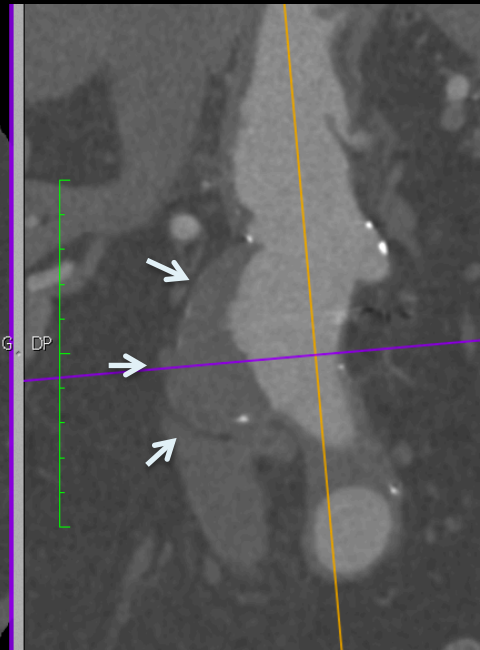
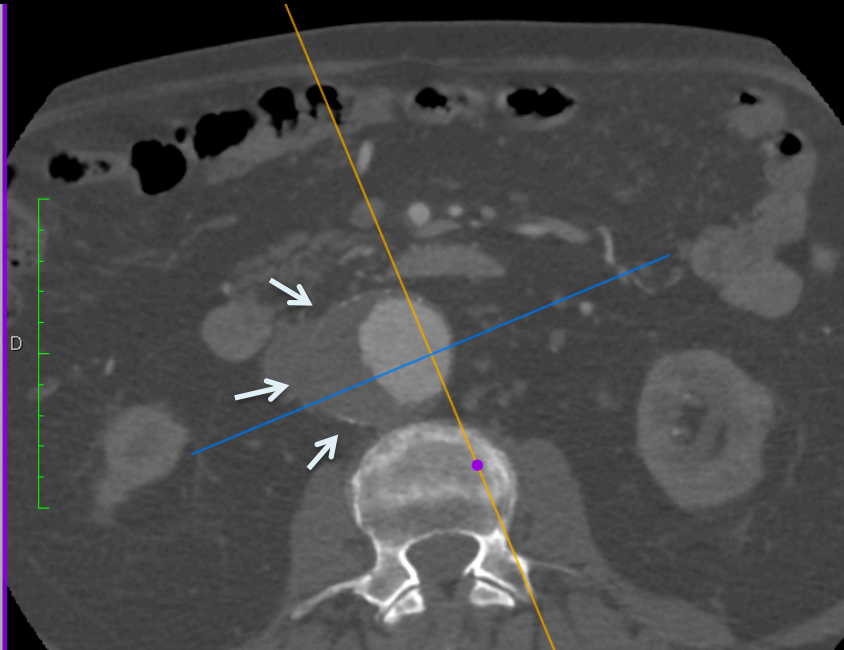
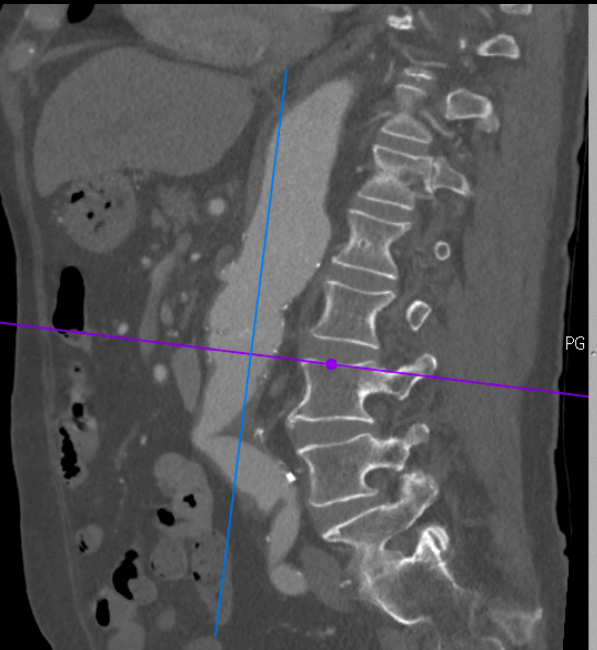
Risque important de thrombose des artères cibles par plicature des stents couverts les alimentant...

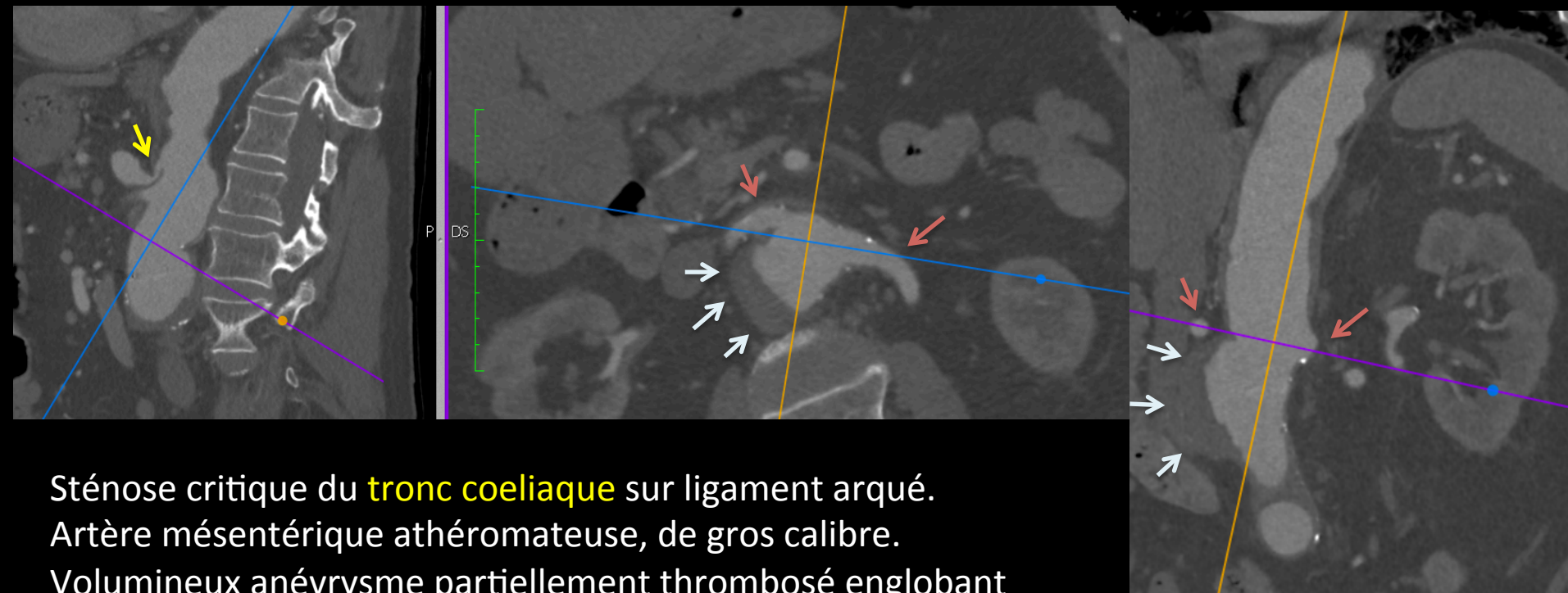
Mr B...84 ans.

Hypertendu, dyslipidémique, tabagique, bronchoemphysémateux.

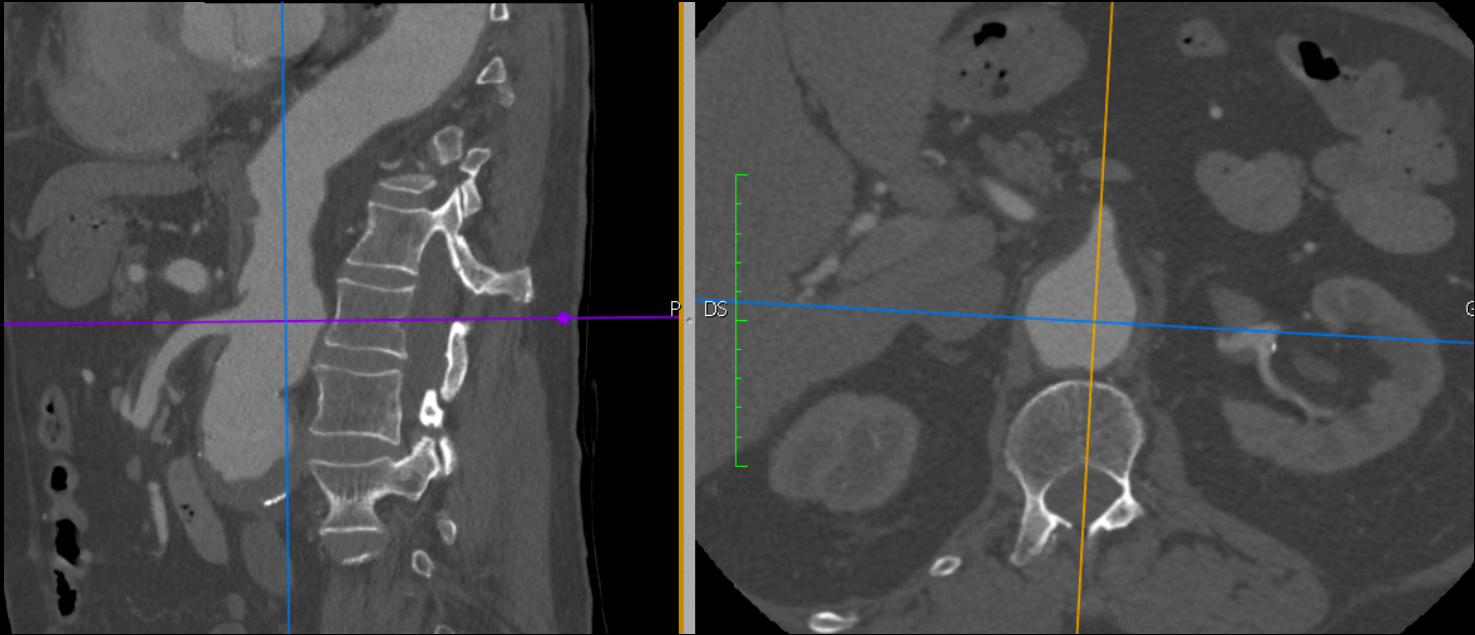
Infarctus postérieur traité par angioplastie primaire en 95.

Fourche aorto bi-iliaque 2003. Volumineux anévrysme de l'aorte abdominale englobant les deux rénales, ayant grossi rapidement en un an pour dépasser les 50 mm.

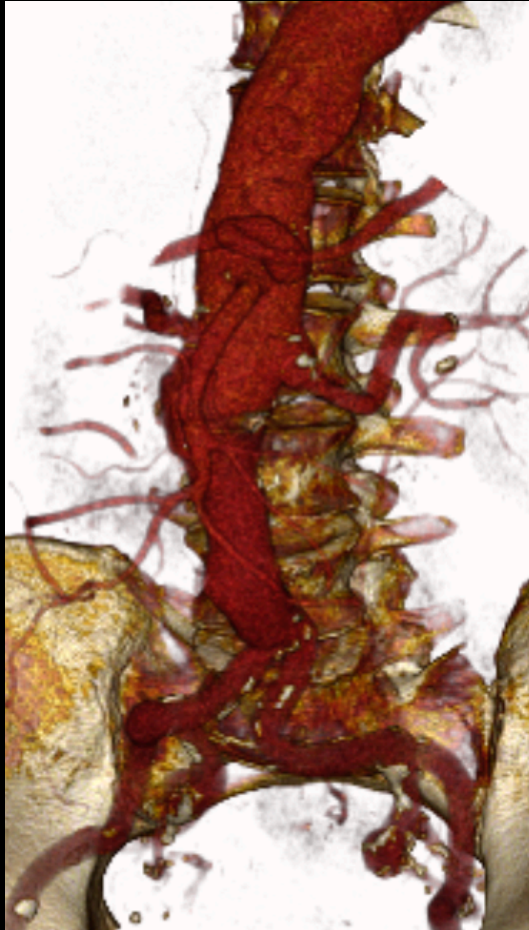




Sténose critique du **tronc coeliaque** sur ligament arqué.
Artère mésentérique athéromateuse, de gros calibre.
Volumineux anévrisme partiellement thrombosé englobant
les 2 rénales, à développement postéro-droit



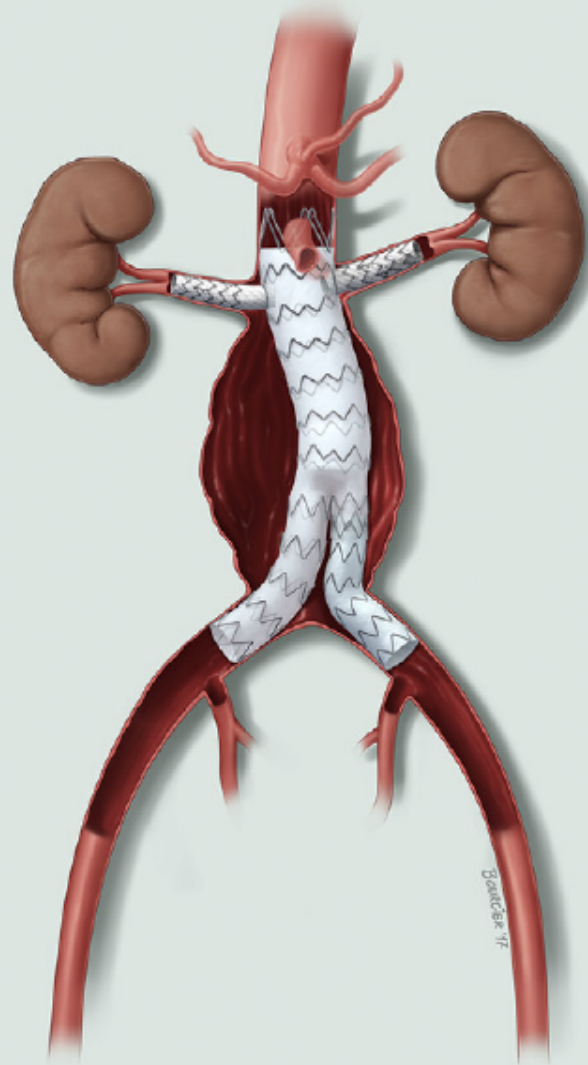
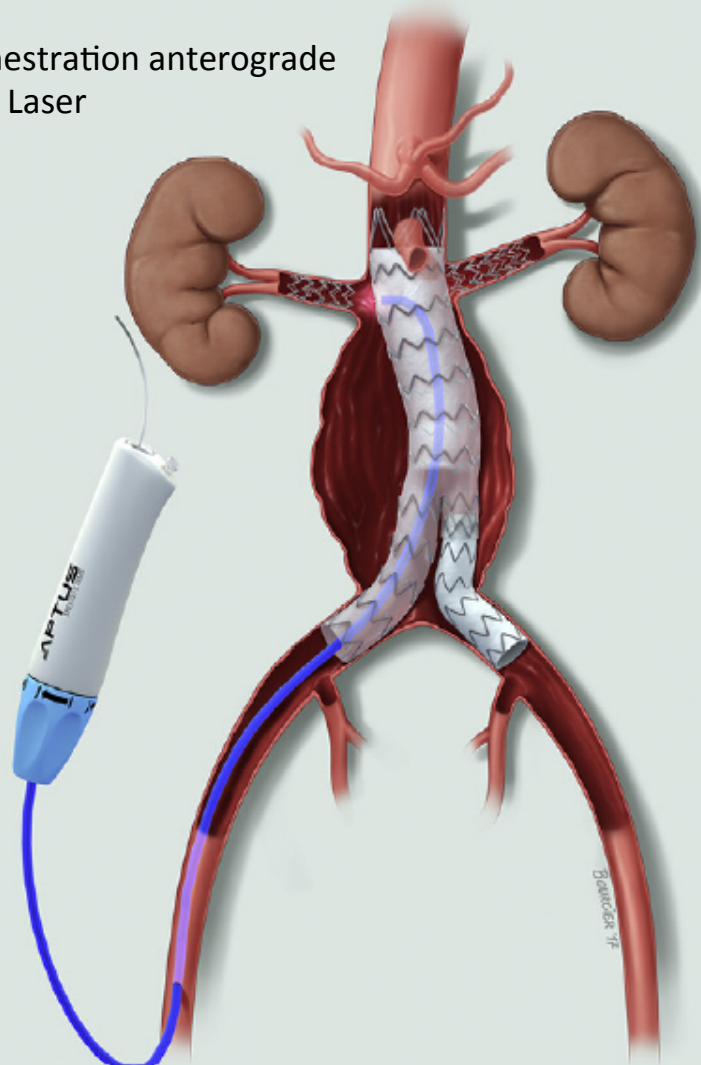
Mésentérique supérieure de gros calibre



D



Fenestration anterograde
par Laser



Laser Generated *In situ* Fenestrations in Dacron Stent Grafts

Eur J Vasc Endovasc Surg (2016) 51, 499–503

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WHAT THIS PAPER ADDS

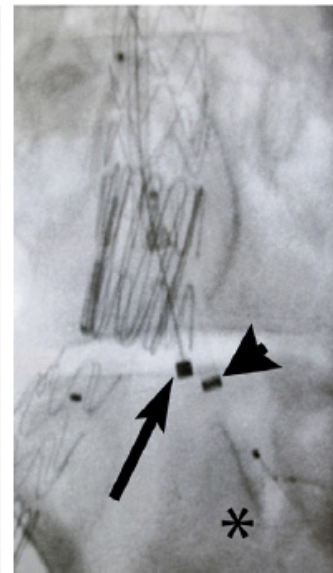
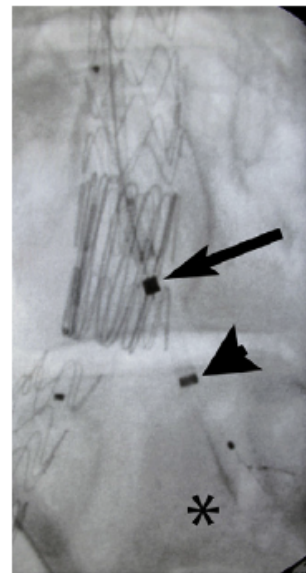
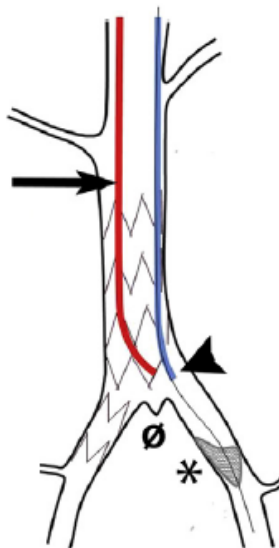
There is an ongoing discussion around whether or not it is safe to cover the left subclavian artery (LSA) during thoracic endovascular aneurysm repair. The standard technique for LSA revascularization is either carotid—subclavian bypass or transposition. These sometimes demanding procedures are associated with a 6–13% mortality/stroke rate. Evolving endovascular techniques for LSA revascularization include *in situ* fenestration. In this experimental porcine model, an excimer laser was used to fenestrate Dacron stent grafts to determine whether graft fabric or coagulated blood embolized during the procedure. No macroscopically visible emboli/clot could be detected. This might indicate safe usage of laser created fenestrations in the arch vessels.

Objective/background: To evaluate if the creation of laser generated *in situ* fenestrations in polyester/Dacron stent grafts causes embolization.

Methods: In seven pigs, Dacron stent grafts were implanted from the infrarenal aorta to the right iliac artery. Prior to placing the stent graft, a carotid artery protection filter, with a pore size of 70–200 μm , was placed in the proximal left common iliac artery. An excimer laser catheter was then advanced antegradely through the stent graft and positioned at the level of origin of the left iliac artery. A fenestration was then created with the laser probe. The carotid filter was retrieved and inspected macroscopically with magnifying glasses, for emboli and clot.

Results: Seven pigs with a median weight of 90 kg (range 78–98 kg) were tested. The median operating time was 170 minutes. All laser fenestrations were successfully completed. No emboli or clot could be detected in the protection filters.

Conclusion: Creation of laser generated, *in situ* fenestrations do not produce macroscopically visible emboli/clot. This might indicate safe usage of laser created fenestrations for endovascular arch repair and left subclavian artery revascularization.



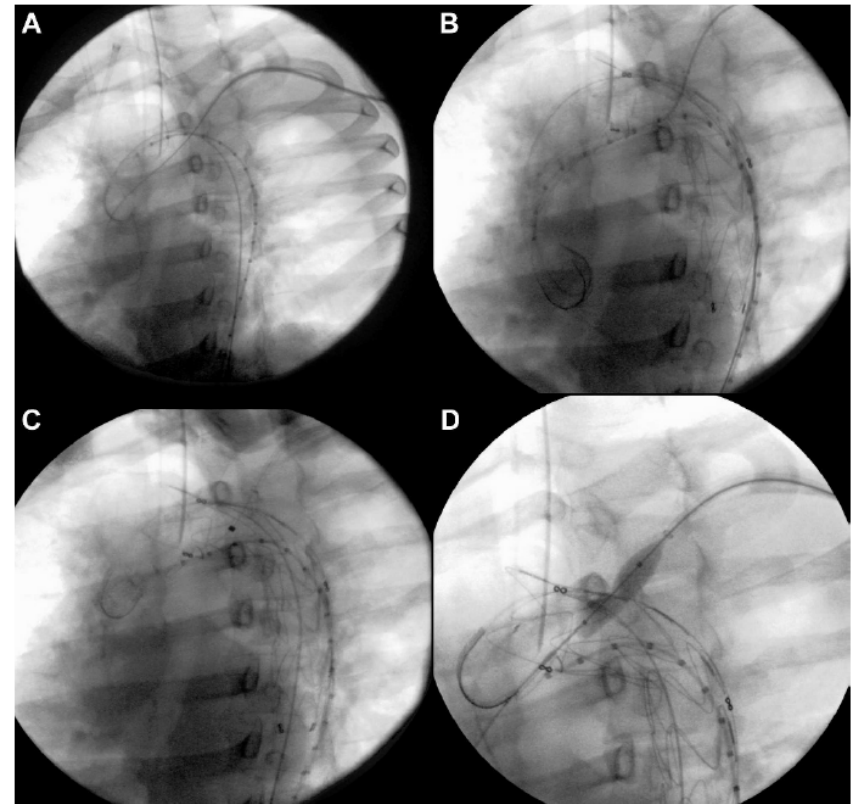
Conclusion: Creation of laser generated, *in situ* fenestrations do not produce macroscopically visible emboli/clot. This might indicate safe usage of laser created fenestrations for endovascular arch repair and left subclavian artery revascularization.

Endovascular Repair of Acute Traumatic Thoracic Aortic Transection With Laser-Assisted In-Situ Fenestration of a Stent-Graft Covering the Left Subclavian Artery

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Michael E. Jessen, MD²; and Frank R. Arko, MD¹

Divisions of ¹Vascular and Endovascular Surgery and ²Cardiothoracic Surgery, University of Texas Southwestern Medical Center, Dallas, Texas, USA. ³United Regional Physicians Group, Wichita Falls, Texas, USA.

Notably, while this procedure was successful with a Talent endograft, we have not yet evaluated this technique with endografts constructed of different fabrics. Prior to our case, we performed in vitro assessment of this laser fenestration technique with the Talent endograft, creating a 2.3-mm fenestrated lumen similar to those created utilizing an ophthalmic cautery. In vitro dilation of the graft material after fenestration produced no tearing of the graft material.



(A) The subclavian artery is cannulated prior to deployment of the thoracic endograft. After deployment of the stent-graft, (B) a laser-assisted in-situ fenestration was made through the orifice of the subclavian artery into the lumen of the thoracic aorta, and (C) the laser was advanced into the aortic arch. (D) The fenestration was stented with an 7-22-mm covered stent to maintain patency and eliminate a potential source of endoleak.

CLINICAL RESEARCH STUDIES

From the Southern Association for Vascular Surgery

In situ laser fenestration during emergent thoracic endovascular aortic repair is an effective method for left subclavian artery revascularization

Richard E. Redlinger Jr, MD, Sadaf S. Ahanchi, MD, and Jean M. Panneton, MD, *Norfolk, Va*

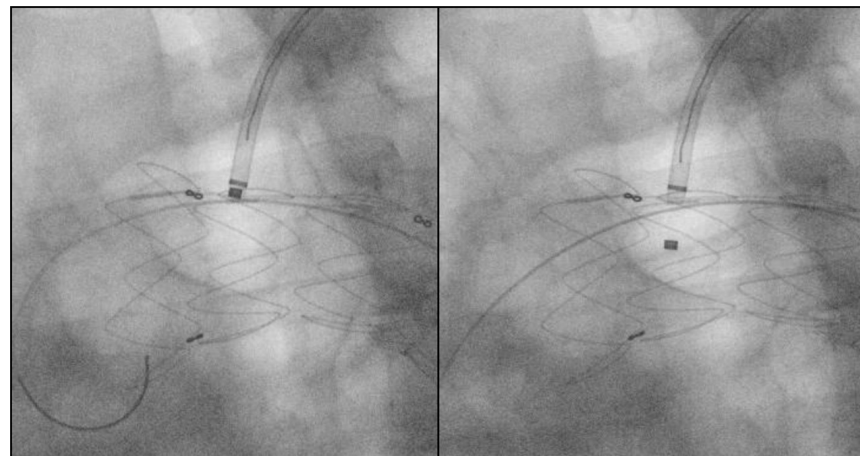
[J Vasc Surg 2013;58:1171-7.](#)

Background: Retrograde laser fenestration of the left subclavian artery (LSA) during emergent thoracic endovascular aortic repair (TEVAR) uses a relatively simple intraoperative method of endograft modification to revascularize aortic branches for a variety of acute thoracic aortic pathologies. This study presents our expanded experience and midterm outcomes of TEVAR with laser fenestration to revascularize the LSA as an alternative to debranching.

Methods: Patients who underwent TEVAR with LSA revascularization by laser graft fenestration from September 2009 through August 2012 were retrospectively reviewed. TEVAR was performed with deployment of a Dacron (DuPont, Wilmington, Del) endograft over the LSA orifice. Laser catheter fenestration of the graft was performed through retrograde brachial access, followed by balloon-expandable covered stent deployment through the fenestration to traverse the endograft and LSA. Routine postoperative follow-up imaging with computed tomography angiography was performed to assess TEVAR and LSA fenestration patency, endoleak, and aneurysm/dissection exclusion.

Results: TEVAR with laser fenestration was successfully performed in 22 patients (12 men; mean age, 57 years) in an urgent or emergent setting secondary to unremitting symptoms or rupture. Twelve patients had large symptomatic thoracic aortic aneurysms (eight secondary to chronic dissection); four patients had acute symptomatic type B aortic dissection, and six patients had an intramural hematoma or penetrating aortic ulcer, or both. An average of two endografts (range, 1-4) were deployed. LSA-covered stents were 8 to 10 mm in diameter. Mean operative time was 154 ± 65 minutes. Average hospital length of stay was 12 ± 7 days. No major fenestration-related complications occurred. One patient developed postoperative paraplegia. One patient died in the postoperative period, for an in-hospital mortality rate of 4.5%. Two patients died of non-TEVAR-related causes at a mean follow-up of 10 months (range, 1-40 months). Follow-up computed tomography angiography imaging demonstrated a 100% primary patency for the LSA stents. One patient had an asymptomatic LSA stent stenosis. Type II endoleaks from the LSA in two patients required endovascular coil embolization. No fenestration-related type I or III endoleaks were noted.

Conclusions: In situ retrograde laser fenestration is a feasible and effective option for LSA revascularization during TEVAR involving a spectrum of acute thoracic aortic pathology. Laser fenestration provides a rapid, reproducible method of fenestrating the endograft material. The high technical success, low fenestration-related morbidity, and excellent midterm patency support this technique of intraoperative endograft modification. (*J Vasc Surg* 2013;58:1171-7.)



TEVAR with laser fenestration was successfully performed in 22 patients (12 men; mean age, 57 years) in an urgent or emergent setting from 2009 through 2012...

A Comprehensive Review of In Situ Fenestration of Aortic Endografts

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^b Faculté de Médecine Paris-Ile de France-Ouest, UFR des sciences de la santé Simone Veil, Université Versailles Saint-Quentin en Yvelines, France

^c UMR 1018, Inserm-Paris11 — CESP, Versailles Saint-Quentin-en-Yvelines University, Paris-Saclay University, Paul Brousse Hospital, Villejuif, France

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WHAT THIS PAPER ADDS

Besides commercially available fenestrated/branched endografts, parallel stent techniques and surgeon modified endografts, evolution of endovascular technologies has rendered possible in situ fenestration (ISF) of aortic endografts. This study documents the means and tools that allow ISF, the clinical settings in which ISF has been performed, and summarizes available results. Although there may be publication bias, high technical success rates and satisfactory short-term results were reported. Long-term outcomes and comparison with alternative techniques are lacking.

Objective: Despite technical advances of fenestrated and branched endografts, endovascular exclusion of aneurysms involving renal, visceral, and/or supra-aortic branches remains a challenge. In situ fenestration (ISF) of standard endografts represents another endovascular means to maintain perfusion to such branches. This study aimed to review current indications, technical descriptions, and results of ISF.

Method: A review of the English language literature was performed in Medline databases, Cochrane Database, Web of Science, and Scopus using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. Sixty-seven relevant papers were selected. Thirty-three papers were excluded, leaving 34 articles as the basis of the present review.

Results: Most experimental papers evaluated ISF feasibility and assessed the consequences of ISF on graft fabric. Regarding clinical papers, 73 ISF procedures have been attempted in 58 patients, including 26 (45%) emergent and three (5%) bailout cases. Sixty-five (89%) ISF were located at the level of the arch, and eight (11%) in the abdominal aorta. Graft perforation was performed by physical, mechanical, or unspecified means in 33 (45%), 38 (52%), and two vessels (3%), respectively. ISF was technically successful in 68/73 (93%) arteries. At 30 days, two (3.4%) patients died in the setting of an aorto-bronchial fistula and an aorto-oesophageal fistula, respectively. No post-operative death, major complication, or endoleak was described as secondary to the ISF procedure. With follow-up between 0 and 72 months, four (6.9%) late deaths were noted, unrelated to the aorta. One (1.7%) LSA stent was stenosed without symptoms.

Conclusions: Although there may be publication bias, multiple techniques were described to perform ISF with satisfactory short-term results. Long-term data remain scarce. Aortic endograft ISF is an off-label procedure that should not be used outside emergent bailout techniques or investigational studies. A comparison with alternative techniques of preserving aortic side branches is needed.

In Situ Antegrade Laser Fenestrations During Endovascular Aortic Repair

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WHAT THIS PAPER ADDS

This article reports a novel technique for the treatment of thoracic-abdominal aneurysm, highlighting the feasibility of laser fenestration in endovascular aneurysm repair.

Introduction: The technique and preliminary outcomes are reported for laser fenestrated endografting (LFEVAR), developed as an alternative procedure for endovascular repair of thoraco-abdominal aortic aneurysms (TAAAs), type IA endoleaks (TIAELs), and pararenal aortic aneurysms (PAAAs).

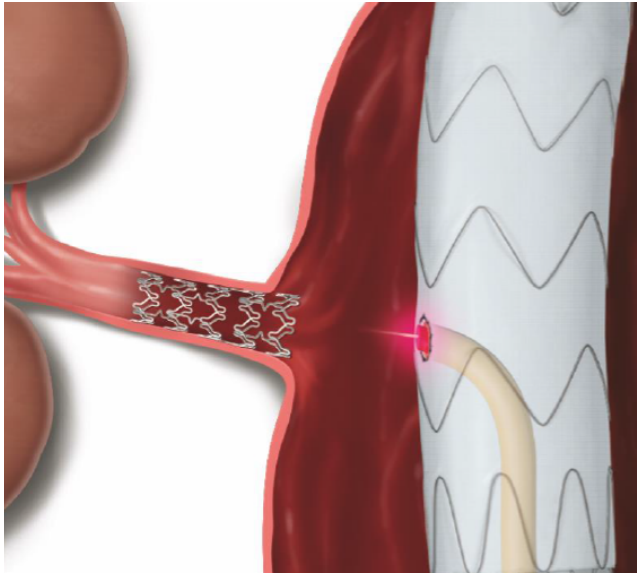
Methods: Patients with TAAA, TIAEL, and PAAA considered unfit for open repair by a multidisciplinary team and who could not benefit from a custom made device were selected. LFEVAR is a physician modified technique requiring sequential steps. After preliminary stenting of each target artery, a standard stent graft was deployed in the aorta. Laser fenestration was performed using a steerable sheath positioned in the stent graft lumen in front of each target artery ostium. After progressive dilation of the laser fenestration, bridging stents were placed and flared to insure accurate perfusion of the visceral arteries.

Results: Between August 2015 and March 2017, 16 consecutive patients were treated using LFEVAR including two TAAAs, four TIAELs, and 10 PAAAs. Thirty-three laser fenestrations were performed with a 94.3% success rate for visceral artery fenestration. The median ischaemic was 7.5 minutes for the superior mesenteric artery, 48 and 50 minutes for the left and right renal arteries, and 125 minutes for the coeliac trunk. Four secondary procedures were required: two endoleaks (type II and III), and two related to fenestrations: one renal stent dislocation, and one renal artery stent stenosis. During a mean follow up of 17 months, no deaths occurred. Follow up computed tomography (CT) scans performed at 30 days, 6, 12, and 18 months were satisfactory (4 endoleaks and two aneurysm enlargements were observed). The follow up CT scan imaging demonstrated 97% primary patency.

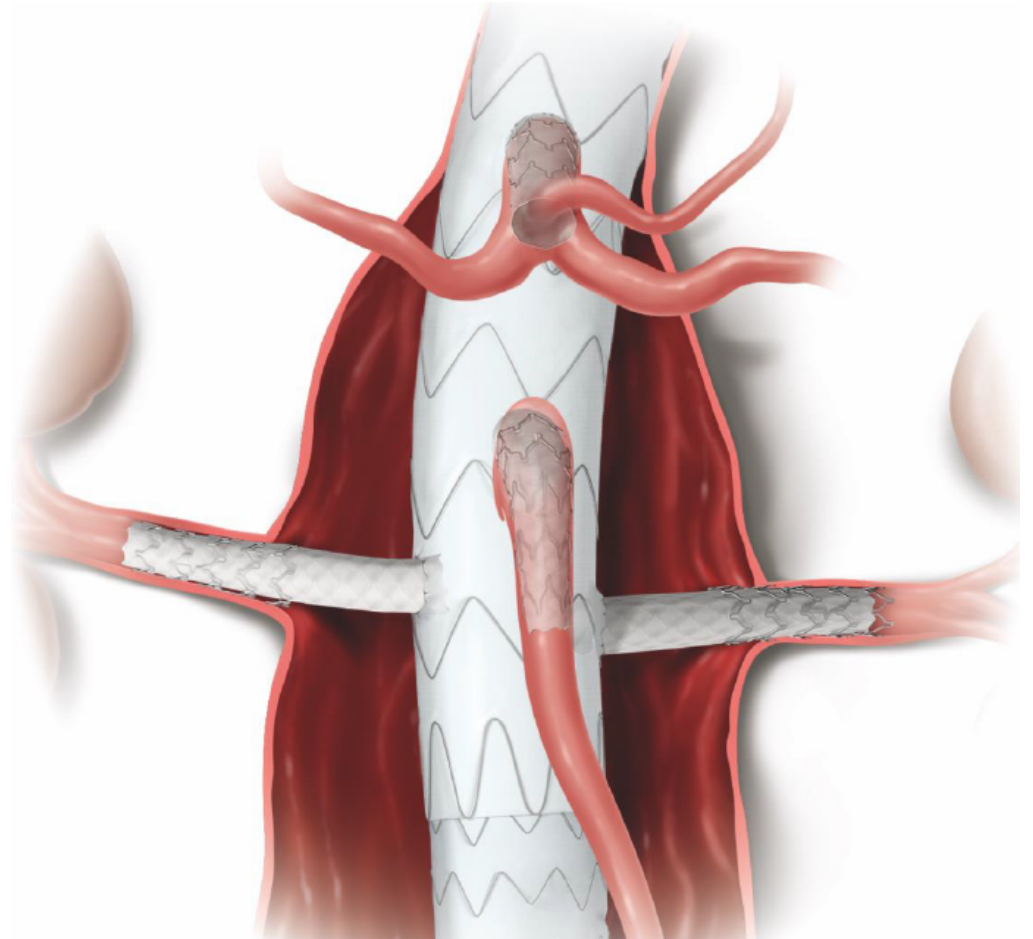
Conclusion: In situ antegrade LFEVAR is feasible and a safe alternative option for high risk inoperable patients for those not eligible for custom made device endografting, particularly in emergency cases.

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Fenestration au laser

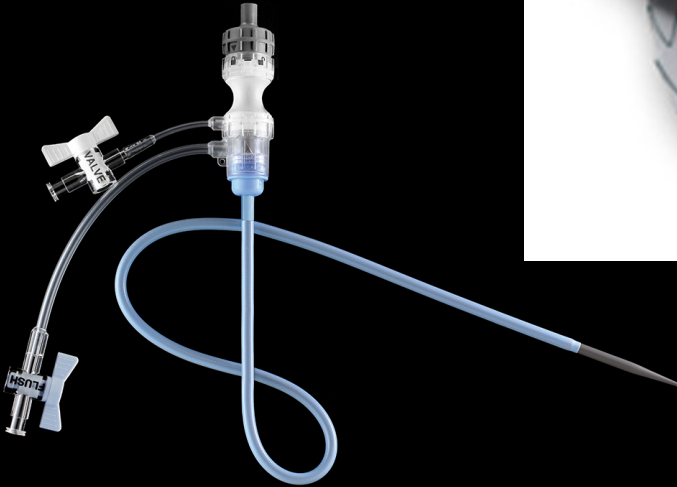


For successful fenestration the laser must be in direct contact with the fabric and also ideally at an angle that is as perpendicular as possible to the target.



1° étape : tatouage des artères cibles par stents

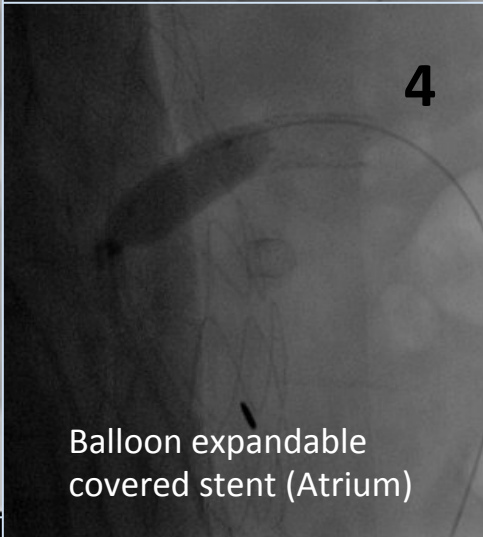
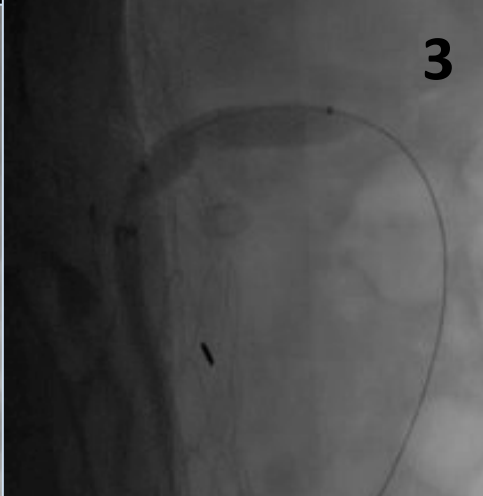
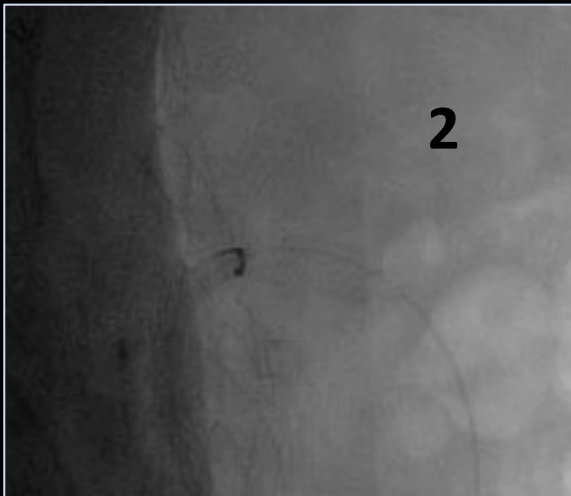
2° étape : pose du stent graft auto expansible par voie fémoro-iliaque

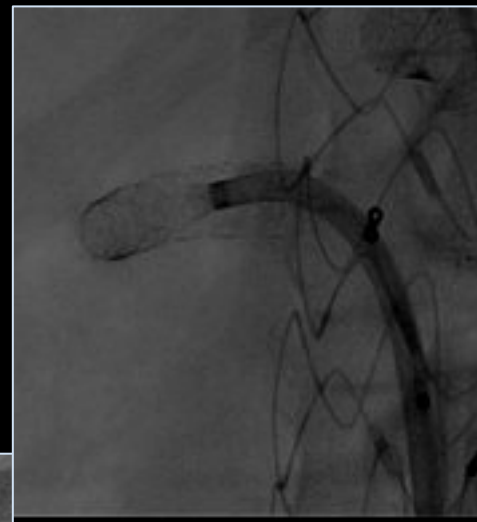


3° étape : fenestration de la prothèse en regard des ostia des artères cibles



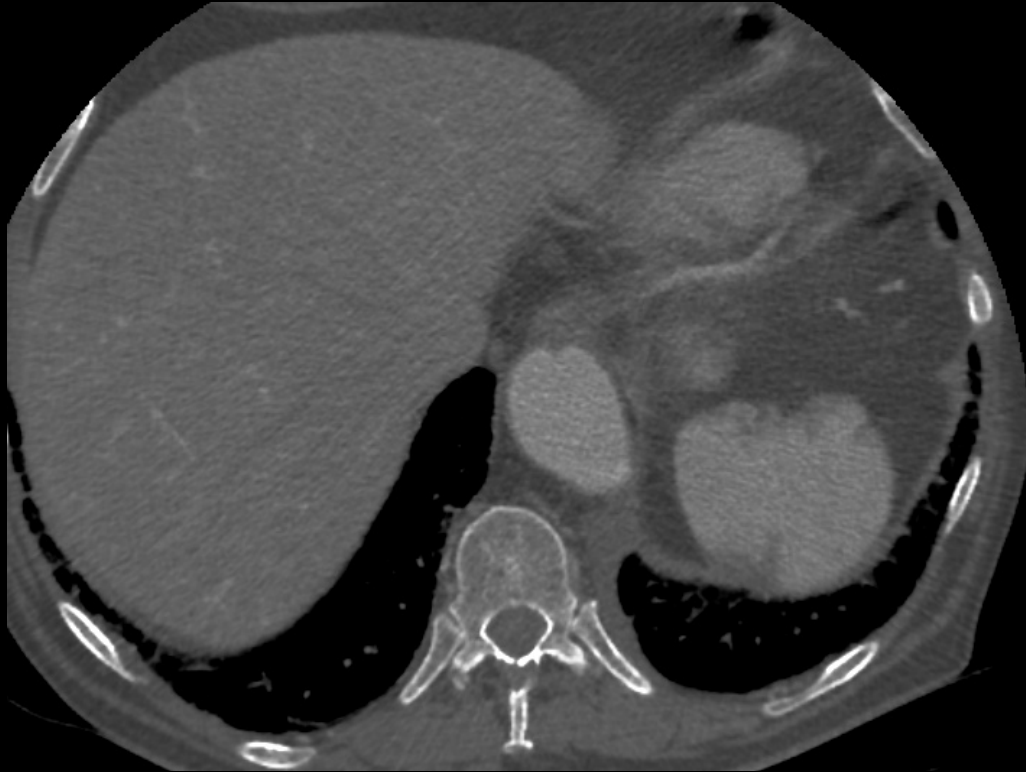
CVX-300 Excimer Laser (Spectranetics).
"cold" laser operating in the ultraviolet wavelength (308 nm)
The mechanism of action is photo ablation, using light to break down molecular bonds thereby vaporizing and fragmenting tissues to molecules.

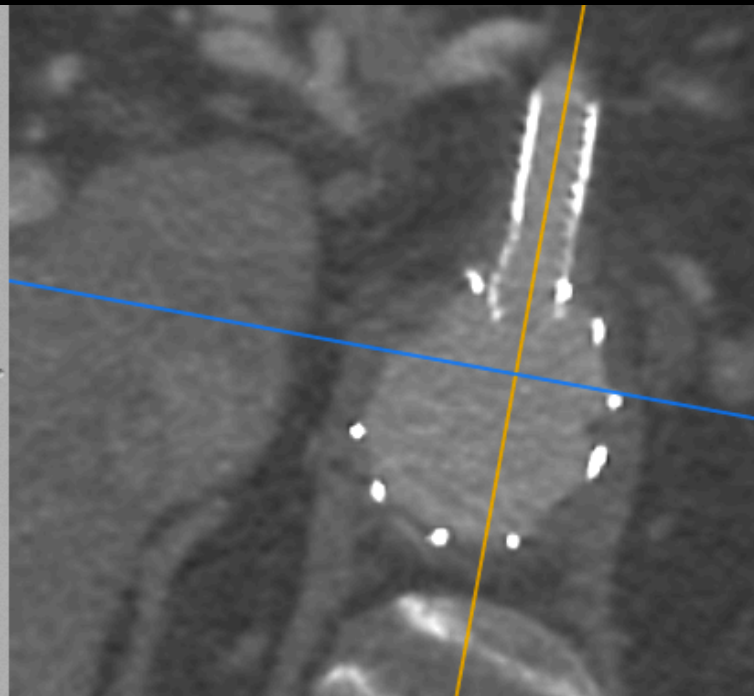
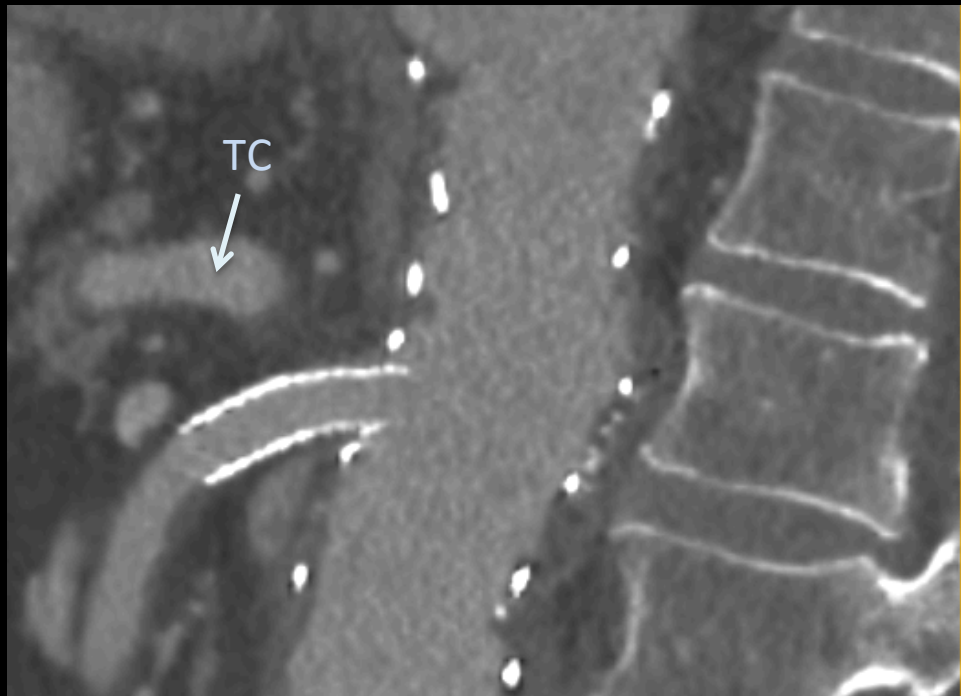




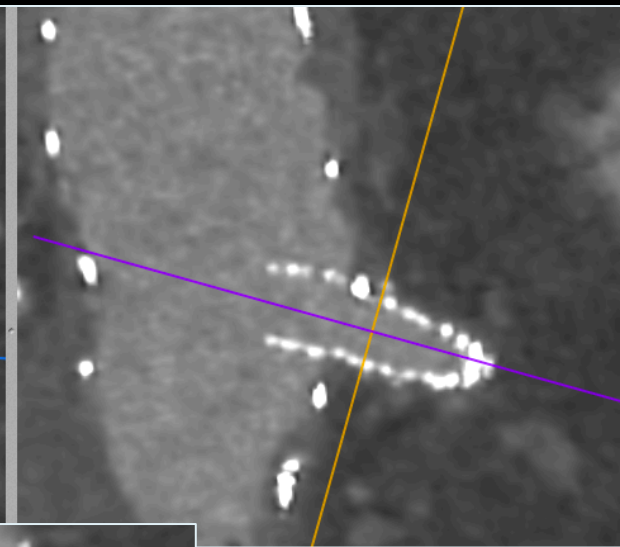
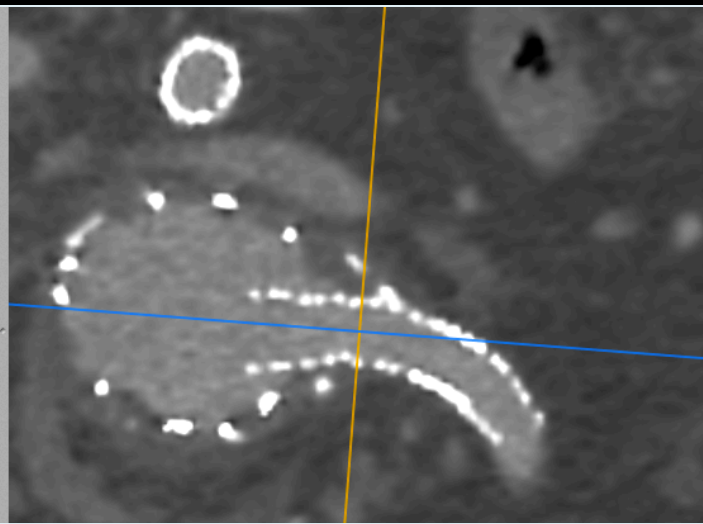
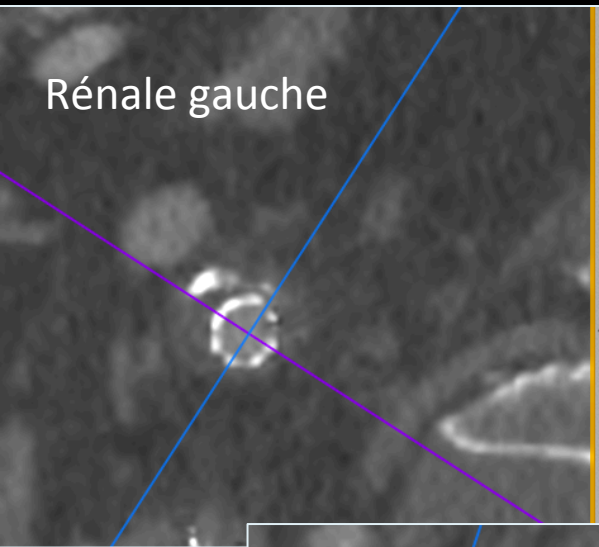
à 3 mois, le patient va bien.

Scanner de contrôle montrant une thrombose de l'anévrysme autour de la prothèse, sans endofuite.
Bonne perméabilité des 3 artères revascularisées et collatéralisation efficace du tronc coeliaque

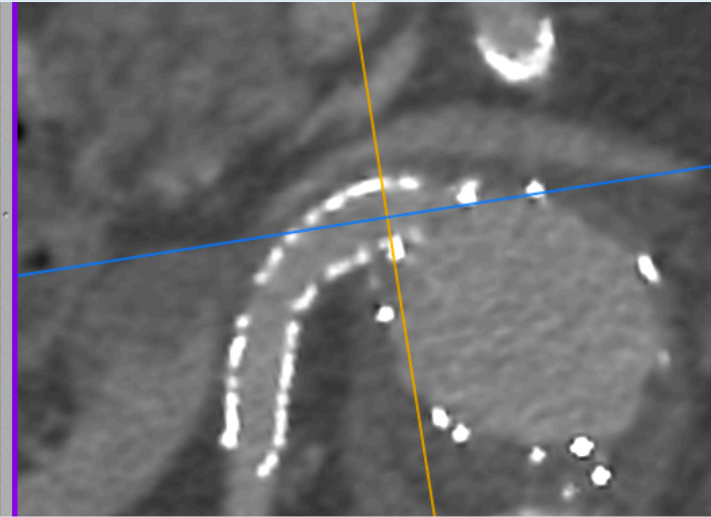
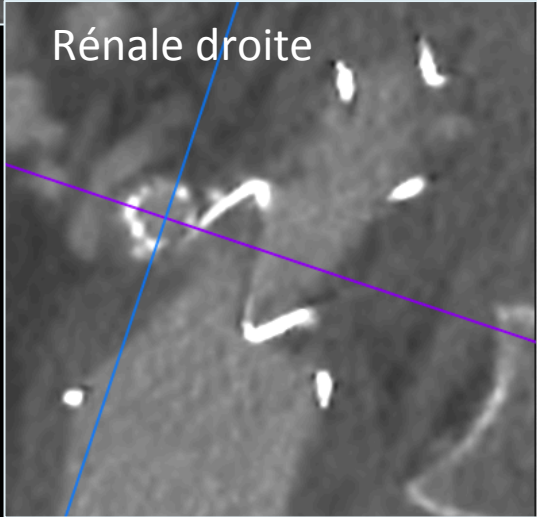




Rénale gauche

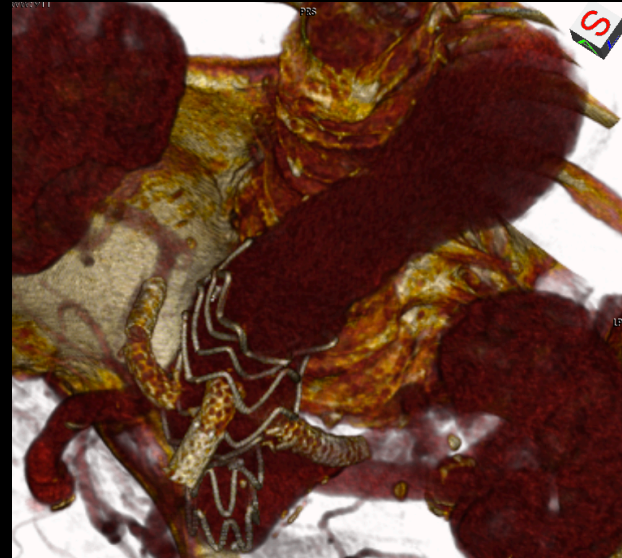
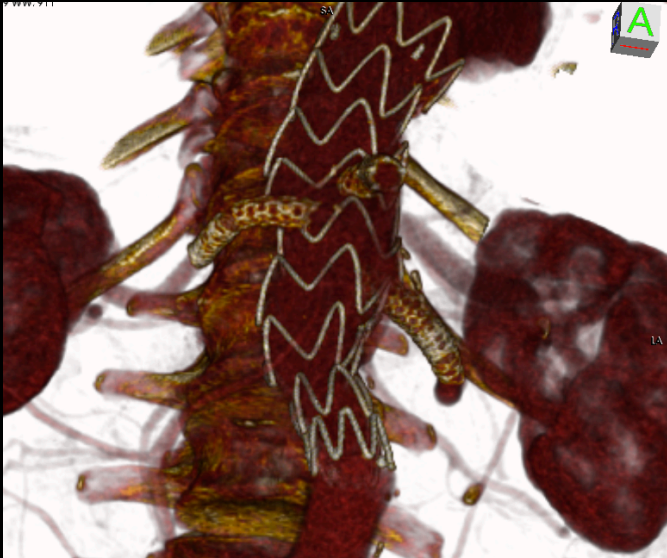


Rénale droite

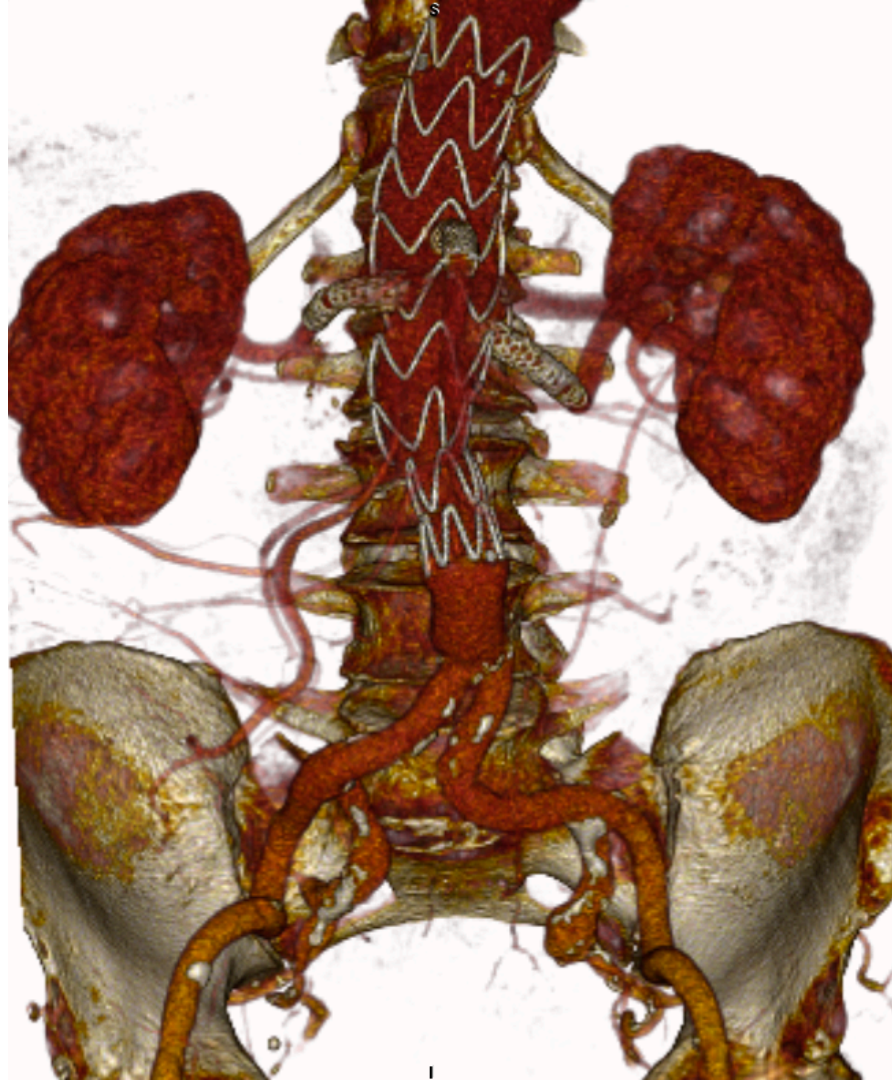


S

A



I



Conclusions :

- ✓ Cette technique prometteuse permet de traiter par voie endoluminale des anévrysmes complexes de l'aorte thoracique et/ou abdominale englobant des artères cérébrales ou viscérales majeures.
- ✓ Elle nécessite un travail d'équipe de préparation et de réalisation de l'acte, faisant intervenir chirurgiens (vasculaires et/ou cardiaques) anesthésistes réanimateurs, radiologues et/ou cardiologues interventionnels...(Aortic team)
- ✓ Elle permet de réaliser une prothèse sur mesure adaptée au patient en salle de cathétérisme, en utilisant du matériel de base disponible dans tout centre expert.
- ✓ Elle peut être réalisée en urgence sur des anévrysmes douloureux...
- ✓ Restent à évaluer le risque de complications (AVC, paraplégies, insuffisances rénales, infarctus mésentériques...) et l'incidence sur le long terme des endoleaks et des occlusions tardives des branches cibles revascularisées ...
- ✓ Elle pourrait permettre de traiter les évolutions anévrysmales péjoratives de la crosse aortique après dissection de type B ou de type A opérée par un tube du secteur I, en évitant une reprise opératoire longue et risquée...

Endovascular Total Arch Repair Using In Situ Fenestration for Arch Aneurysm and Chronic Type A Dissection

Yoshiaki Katada, MD, PhD, Shunichi Kondo, MD, PhD, Eitoshi Tsuboi, MD, PhD, Kyu Rokkaku, MD, PhD, Yoshihito Irie, MD, PhD, and Hitoshi Yokoyama, MD, PhD

Department of Cardiovascular Surgery, Iwaki Kyoritsu General Hospital, Fukushima, Japan; Department of Diagnostic Radiology, Tokyo Medical and Dental University, Tokyo, Japan; and Department of Cardiovascular Surgery, Fukushima Medical University, Fukushima, Japan

Background. Total arch replacement and ascending aorta and arch replacement are the gold standard treatments for aortic arch aneurysm and are possible treatment strategies for chronic type A dissection, with good reported outcomes. However, because total arch replacement is extremely invasive, it can be difficult to perform in some patients. We designed an endovascular total arch repair procedure with the use of in situ fenestration and commercially available devices, and we present our initial experience.

Methods. Seven patients (chronic type A aortic dissection, $n = 3$; thoracic arch aneurysm, $n = 4$) who underwent endovascular total arch repair with the use of in situ fenestration thoracic endovascular aortic repair from a zone 0 landing were retrospectively analyzed. All the procedures were performed under general anesthesia and cardiopulmonary bypass. The triple branches were manually punctured in a retrograde manner with the use of an 18-gauge/30-cm needle or a 21-gauge aspiration

needle, and all the branches were reconstructed with the use of stent grafts; balloon touch-up was performed if appropriate.

Results. The procedure was successful in 6 of the 7 patients; the remaining 1 patient additionally underwent an axillary-axillary artery bypass during the operation because the left subclavian artery was difficult to puncture. All the patients had an acceptable postoperative course, with no 30-day and in-hospital deaths. None of the patients had endoleaks, and all the patients exhibited a reduction in aneurysm diameter or thrombosed false lumen during a mean follow-up period of 17.6 months.

Conclusions. Endovascular total arch repair with the use of in situ fenestration can be performed with commercially available devices with acceptable interim results.

(Ann Thorac Surg 2015;■:■-■)

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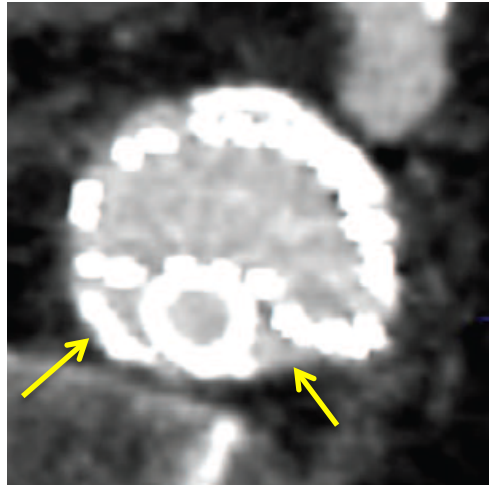
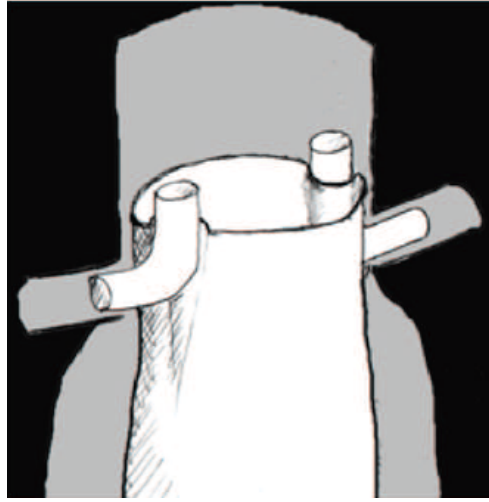


3 TYPES DE TRAITEMENT DES ANEURISMES THORACO ABDOMINAUX

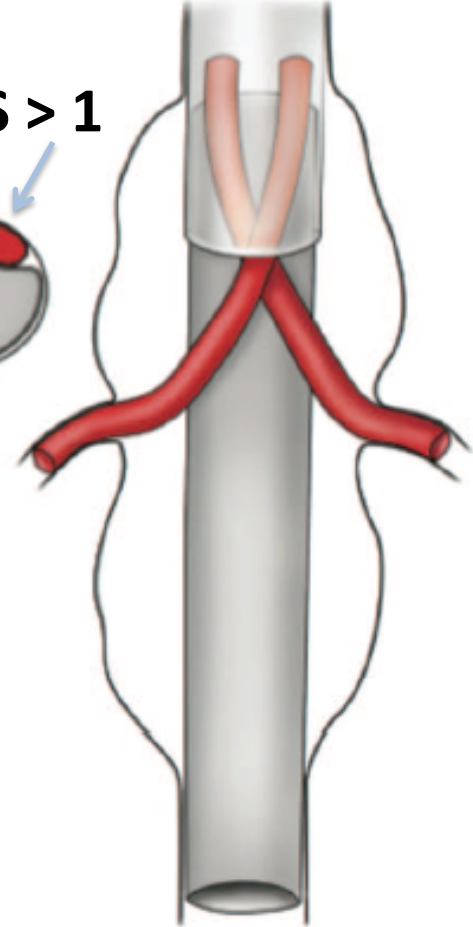
ENDOPROTHESE AVEC CHEMINEE(S)

ENDOPROTHESE BRANCHEE ET FENETREE

FENESTRATION LASER IN SITU



ENDOPROTHESE AVEC CHEMINEES > 1



Cette technique apparait de plus en plus comme **obsolète** car au delà de l'utilisation de 2 cheminées le risque d'endofuite de type I et de thrombose des stents de revascularisation des artères cibles est très élevé.

ENDOPROTHESE FENETREE BRANCHEE

AVANTAGES

Technique de référence du traitement des anévrismes thoraco-abdominaux
Fenestrations renforcées par un anneau NITINOL

INCONVENIENTS

Production de l'endoprothèse 4 a 6 semaines

Le coût est probablement plus élevé 15 / 18000 euros que la F.L.S

Technique de réalisation relativement compliquée

Impossibilité de réaliser des traitements en urgence des anévrismes fissurés et rompus

FENESTRATION LASER IN SITU (FLS)

- LA TECHNIQUE DE FENESTRATION LASER IN SITU EST CONSIDEREE COMME UNE PROCEDURE ALTERNATIVE POUR LE TRAITEMENT ENDOVASCULAIRE DES ANEURISMES THORACO ABDOMINAUX , PARA RENAUX ET DES FUITES DE TYPE IA
- CETTE TECHNIQUE N'EST ACTUELLEMENT PAS VALIDEE MAIS PRESENTE DES AVANTAGES CERTAINS

Fenestration laser in situ

Avantages

- technique développée depuis 15 ans pour la fenestration des artères sous clavières (bon résultat à 2 ans)
- procédure interventionnelle est réalisable immédiatement ou en moins de 24 heures
- réduction du temps d'exclusion de l'anévrisme en cas de rupture
- technique simple du fait de l'utilisation d'un cathéter orientable (APTUS DE 12 FR)

INCONVENIANTS

La première est la création de fenestration non renforcée par un anneau de nitinol qui permet en théorie d'éviter la déconnexion ou le détachement tardif des stents réunissant l'endoprothèse à l'artère cible

Dans le série de l'Hôpital Marie Lannelongue (Dr D.FABRE) une seule déconnexion a été rapportée à 1 an nécessitant une intervention secondaire

L'absence de suivi à long terme de la fenestration laser in situ.

Ce suivi à long terme est évidemment nécessaire.

SERIE de IAT fevrier 2017 /juin 2018

- SERIE DE 11 MALADES
- 8 hommes 3 femmes
- Age moyen : 73 ans
- Nombre artères fenestrées: 31
- Anévrismes 5 Crawford de type I et 6 de type 3
- ENDURANT medtronic de type II
- Suivi moyen des malades 7 mois (Evaluation trop courte du suivi)

Temps d'ischémie moyen

- Artère mésentérique supérieure 10 MN
- Artère rénale 31 MN
- Artère rénale contro-latérale 62 MN
- DOSE IRRADIATION > 60 GRAY (dose élevée)
- Echec de revascularisation artère cible 0

Suivi des malades

- SEJOUR EN REANIMATION 3 A 10 JOURS
- DMS 8 JOURS
- COMPLICATIONS
 - mortalité 0
 - conversion chirurgicale 0
 - ischémie mésentérique 0
 - endofuite de type II à 30 jours 1
 - Interventions secondaires 2 (pont croisé, thromboendartériectomie ilio-fémorale)
 - Hémothorax 1 (drainé sans récidence)
 - Insuffisance rénale aigue 0
 - Dialyse 0
 - Paraplégie 0
 - endofuite de type III (à 20 mois) qui va nécessiter une réintervention Crawford de type 1

Série de Hopital Marie-Lannelongue

Dominique Fabre MD Stephan Haulon PR

- Série 16 malades aout 2015 à mars 2017
- 33 fenestrations avec un taux de succès de 94.3%
- Temps moyen ischémie A. mésentérique supérieure 7.5 mn
- 48 et 50 mn pour les artères rénales droite et gauche
- Durée moyenne de suivi a été de 17 mois

Résultats H.Marie Lannelongue

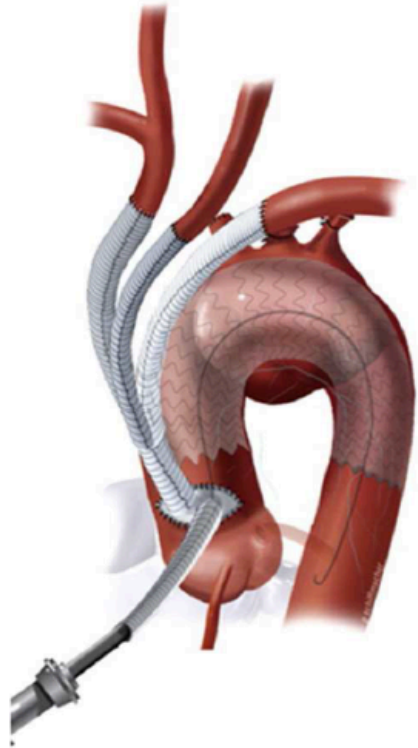
- 4 procédures secondaires ont été nécessaires pour des endofuites de type II et III
- 1 désinsertion d'un stent rénal
- 1 sténose d'une artère rénale
- Mortalité 0
- Surveillance : 4 endofuites et 2 augmentations de volume de l'anévrisme
- Insuffisance rénale aigue 4
- Dialyse 3
- Complications locales 2
- **AU TOTAL 97 % DE SUCCES PRIMAIRE**

SYNTHESE

- La fenestration laser in situ présente des avantages certains par rapport aux endoprothèses fenêtrées et branchées , permet le traitement en urgence des ATA fissurés ou rompus
- Technique relativement simple
- L'importance de l'équipe de spécialistes qui doit être associée
 - cardiologue interventionnel
 - chirurgien cardiaque
 - équipe d'anesthésiologie
 - radiologue interventionnel
 - chirurgien vasculaire

Une évaluation à plus long terme de la FLS est absolument nécessaire.

L'importance du plateau technique : la FLS ne peut être réalisée avec des appareils de radiologie classique car leur puissance est insuffisante pour réaliser cette technique notamment pour la fenestration des artères rénales .

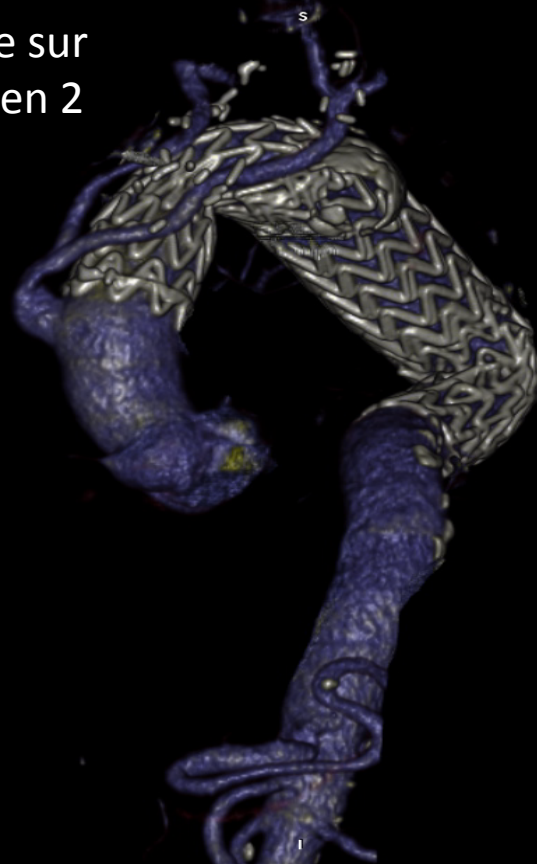
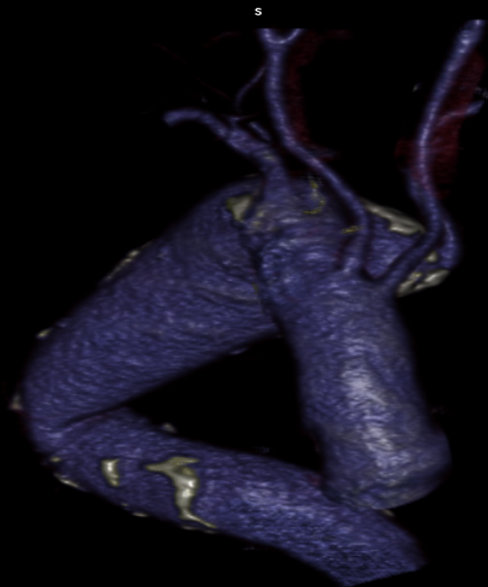


Mr C...70 ans : volumineux anévrisme de la crosse sur une variante anatomique congénitale rare, traité en 2 temps : debranching puis stenting.

AG

WL: 270 WW: 364

RA



PG

S-I: -3.1
L-R: 51.4
Roll: -1.6

On pourrait envisager chez des patients fragiles de réouvrir les ostia des TSA par voie rétrograde au Laser, puis de faire la jonction par stent graft.....