Initial Experience with an Automated Suture-Fastening System (COR-KNOT®) in Aortic and Mitral Valve Surgery

COR-KNOT MINI® (LSI Solutions, U.S.A.) is a mechanical device to knot (fasten, in fact) automatically the suture knots in an aortic valve replacement or annuloplasty. The device includes a system of titanium fasteners or clips that slide over the suture strands, fasten the threads, and automatically cut the remains. While this system facilitates knotting in minimally invasive approaches –where the reduced space makes manual tying difficult–, it is also useful for a traditional sternotomy.

For the time being, reports in the literature are scarce; however, it has been proposed that these devices could significantly shorten the time needed for mitral valve surgery. In experimental studies, the strength, consistency, and speed of this method to attach sutures were compared with manual knots using laboratory animals, with positive outcomes. (1, 2) Other authors say that those titanium clips might serve as a radiopaque marker of the annular plane for future valve-in-valve implantation, (3) or for any other less common surgery. (4) Recently, we have used this device in single or combined valve replacements with conventional sternotomy. It was a series of 15 patients who were implanted 17 prosthetic valves fixed with the COR-KNOT® system.

On average, 15 clips per valve were used, with a mean cost of USD 1000 per valve. From a technical point of view, once the knots on the prosthesis and valve annulus had been put through, loading each pair of threads in the system through a loop was simple and quick, as well as unloading each clip, generating a feeling of security and firmness in the fixation of the prosthesis (Figure 1).

Table 1 shows the patients' characteristics and the comparison between clamping and perfusion times in minutes with the use of automated fastener or the manual system. The control group with manual knotting corresponded to a historical series of identical procedures. Although the sample size did not allow to draw statistical conclusions, automated fastening in most procedures did not seem to reduce clamping times, except for the two cases of combined mitral replacement with myocardial revascularization. In any case, those times might be reduced after more experience with the device.

In this small series, there was no mortality or other major event that might be related to mechanical suturing. Figure 1 shows the typical ultrasound image

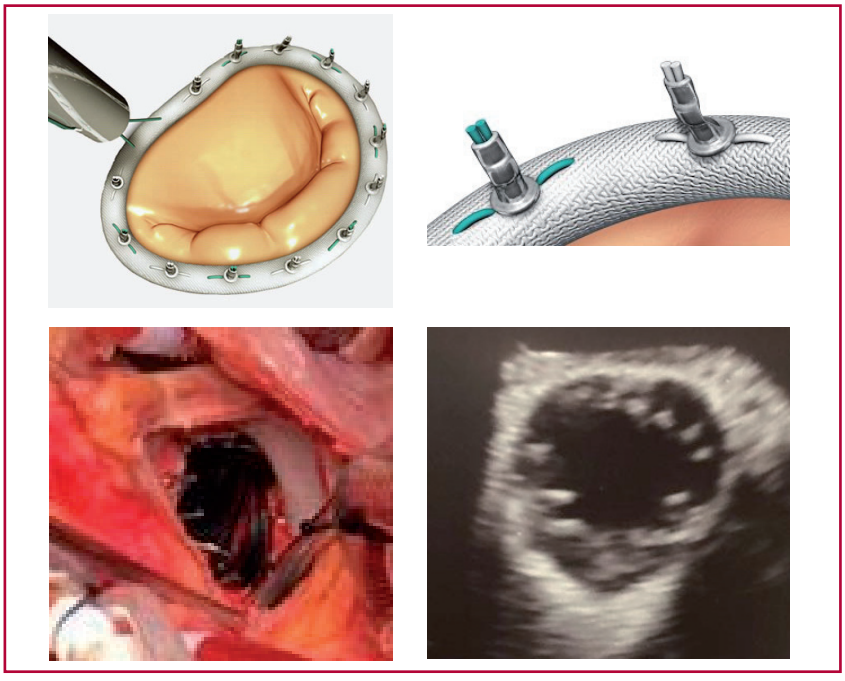

Fig. 1. Upper panel: application scheme of automated fastener (the applicator end can be visualized) and detail of the clips, once adjusted. Lower panel, left sector: intraoperative picture showing the clips in the prosthetic mitral valve annulus; lower panel, right sector: shark-jaw transesophageal echo-Doppler view after aortic valve replacement (the 'teeth' correspond to the crown of titanium clips).

Table 1. Patients' characteristics, and comparison of perfusion and clamping times with the use of automated fastener COR-KNOT® (time expressed in minutes).

	Age (years)	Sex	Euro SCORE II	ECC time (autom.)	Clamping time (autom.)	ECC time (manual)	Clamping time (manual)
Double replacement	53	M	1.58	120	90	113 ± 16	84 ± 14
Double replacement	80	M	2.61	115	85	-	-
AVR + CABG	69	M	1.24	90	60	80 ± 13	56 ± 8
AVR + CABG	73	M	8.17	90	70	-	-
AVR + CABG	73	M	1.38	75	55	-	-
AVR + CABG	71	F	3.54	70	60	-	-
MVR + CABG	62	M	1.39	70	50	96 ± 21	66 ± 12
MVR + CABG	74	M	1.61	90	50	-	-
AVR + AsA	55	F	3.04	70	49	74 ± 18	51 ± 7
Single AVR	65	F	1.15	60	45	62 ± 11	42 ± 7
Single AVR	65	M	0.64	60	40	-	-
Single AVR	82	M	3.51	60	40	-	-
Single AVR	77	M	2.11	55	39	-	-
Single AVR	66	M	0.66	61	40	-	-
Single MVR	52	M	0.80	70	45	67 ± 13	47 ± 10

AVR, aortic valve replacement; MVR, mitral valve replacement; CABG, coronary artery bypass graft; AsA, ascending aorta; ECC, extracorporeal circulation.

of the crown of titanium clips in the prosthetic annulus, shaped like a shark jaw. (See video on the web.)

Although immediate outcomes were positive, the procedure awaits further long-term follow-up studies to evaluate its safety and usefulness. A case of perforation was observed in one of the bioprosthetic leaflet in aortic position was recently reported, as a result of perforation and tearing caused by the free end of the COR-KNOT®. (5) This can occur when the remaining metal button is not perpendicular but inward to the valve annulus: this situation is more common in case of intra-annular prosthesis. With the new holding models, it is recommended to position the applicator so that the free end of the remaining clip is not oriented toward the center of the valve prosthesis. Some cases of paravalvular leak have also been reported with the use of this device, which may also depend on the position of the applicator at the time of triggering. (7) Automated fastening devices will undoubtedly be of great help for minimally invasive approaches. In the meantime, it would be advisable to have an initial experience with conventional surgeries to adapt to these new tools.

Conflicts of interest

None declared.

(See authors' conflicts of interest forms on the website/Supplementary material).

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Carbon Dioxide Procedure for the Treatment of a Type-II Endoleak Without Using Iodinated Contrast

Endovascular treatment has become one of the treatment modalities for abdominal aortic aneurysm (AAA), especially in patients with suitable anatomy. The benefits of this approach include less short-term morbidity and mortality. In this report, we point out two important aspects of this approach. On the one hand, the need to use contrast dyes to place the de-

vice, and on the other hand, the presence of endoleaks as a postoperative complication.

The use of iodinated contrast in the endovascular approach may lead to adverse events in patients with allergy to contrast dye or at risk for contrast-induced nephropathy. (1) Carbon dioxide is a non-nephrotoxic, nonallergenic gas, and a potential substitute for iodinated as contrast dye.

The use of carbon dioxide (CO2) has been widely studied, especially since the advent of a safe and efficient management system (such as the injection pump), together with the imaging software for acquisition and post-processing. In this case, the presence of a type-II endoleak from the left iliolumbar artery was determined by carbon dioxide digital subtraction angiography (CO2-DSA).

On the other hand, treatment of type-II endoleaks is generally recommended in the presence of aneurysm sac growth. What has not yet been defined is which of the different methods is associated with the best results.

The purpose of this report is to show the first national experience with a new endovascular approach without the need to use iodinated contrast, with the mechanical infusion pump of CO2 to detect and guide the treatment of a type-II endoleak.

We report the case of a 78-year-old man who consulted for progressive aneurysm sac growth (diagnosed with Doppler echocardiography, non-contrast CT scan, and simple abdominal X-ray), secondary to type-II endoleak. The patient had a history of non-dialysis chronic renal failure, chronic obstructive pulmonary disease, and stent placement due to aneurysm of the abdominal aorta in 2010.

During subsequent follow-ups, type-II endoleak was determined by CT scans, until it reached 76 mm and its treatment was decided. (Figure 1) The X-ray also showed a small contralateral branch migration in the insertion into the contralateral stump.

With an injection of 100 ml of CO2 at 300 mm through a femoral introducer and an automatic injection (Angiodroid Srl., San Lazzaro, Bologna, Italy), a type-II endoleak was evidenced at the expense of the iliolumbar artery, branch of the left hypogastric artery (Figures 2a & 2b). After selective cannulation, a nidus in the aneurysm sac was evident, which also had an efferent lumbar branch. Embolization with fiber coils (Concerto 3D Detachable Coil System, Medtronic, Santa Rosa, USA) of the afferent and efferent branches and of the endoleak nidus was decided. A 13 mm-diameter Cook iliac extension (Cook Inc., Bloomington, IN, USA) was then placed to repair the type-II endoleak. (Figure 2c)

The use of CO2 angiography was first developed by Hawkins in 1982. (2) Since then, CO2 has been recognized to have many advantages that turn it into an effective contrast agent for the angiography. (3, 4) Two of the most attractive characteristics of CO2 is that it is neither nephrotoxic nor allergenic. To take advantage of those CO2 properties requires an advanced modality of fluoroscopic imaging acquisition, in addition to a specific software to post-process those images.

So far, several studies have demonstrated the safety and viability of CO2 angiography in endovascular aneurysm repair (EVAR). (5) However, sensitivity and positive predictive value for type-II endoleak detection were poor. (6) According to previous reports, it can be associated with the fact that CO2 is a gas and the location of lumbar branches is posterior to it. With the patient in supine position, it is unlikely that CO2 will be distributed backwards; hence the importance of selective cannulation and the position of the stretcher in trendelenburg position. On the other hand, we believe that the blood flow speed and volume may contribute to visualization rather than the artery location.

Most type-II endoleaks disappear during the follow-up period. Only persistent type-II endoleaks can be a clinical problem associated with aneurysm sac growth, increased rate of reintervention, need for conversion to open surgery, and rupture. In patients with persistent type-II endoleak (> 6 months), more frequent follow-up or reintervention should be considered. This case revealed that the CO2 approach may be an option to detect and guide the treatment of patients with type-II endoleaks, with a reduction of contrast dye dose and, therefore, of the risk of contrast

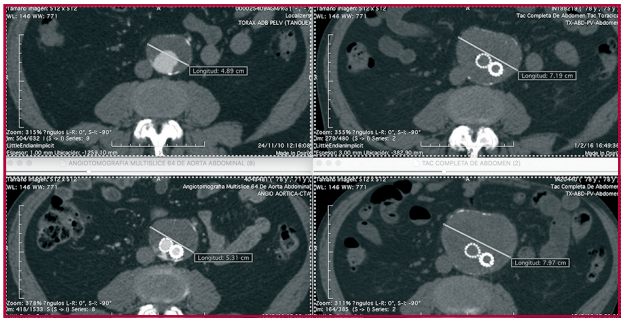

Fig. 1. Follow-up CT scan images show aneurysm sac growth from A (preoperative, 2010) to D (2018).

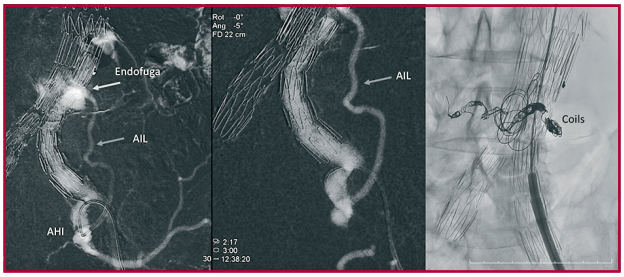

Fig. 2. A & B, CO2 angiography: the left hypogastric artery (HGA) and its collateral branch (ILA, iliolumbar artery) are shown feeding type-II endoleak. Final outcome with embolization with coils of the afferent artery, efferent artery and endoleak nidus with coils.

induced nephropathy in patients with renal dysfunction.

The injection of non-toxic CO2 through an automated device allowed this procedure to be carried out effectively. For these endoleaks in particular, the use of CO2 allows for correct visualization when compared to standard contrast dye, with a significant benefit to renal function.

Conflicts of interest

None declared.

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A Special Type of Complex Coarctation of Aorta with Total Lumen Occlusion Treated by Radiofrequency

Coarctation of aorta (CoA) accounts for 7% - 10% of cases of congenital heart disease. (1) Aortic atresia (complete aortic occlusion) is a special and very uncommon type characterized by the total absence of distal flow, but with luminal continuity between the ascending and descending aorta. Normally occurs in cases of untreated long–standing CoA which progress to complete occlusion. (2,3)

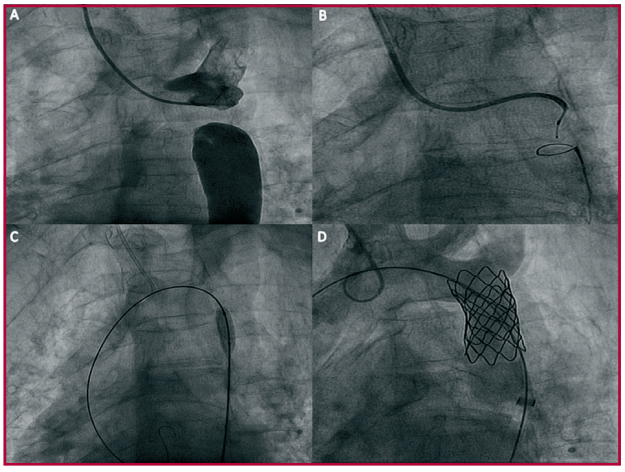
Diagnosis is usually established in the context of the study of HTA, stroke or heart failure. It´s usually accompanied by extensive collateral circulation and degeneration of aortic wall which can trigger complication such as aneurysm and dissections or even aortic rupture. Surgical treatment is associated with a high rate of morbidity and mortality, and for this reason percutaneous treatment has become relevant in recent years.

A 60-year-old male patient with non-controlled hypertension, ischemic stroke 2 years ago without consequences, and normal left ventricular EF, who was referred to our center due to the casual finding of an aortic atresia, in order to try to solve it by percutaneous access.

We performed the procedure by dual arterial access (radial and femoral) under general anesthesia, the occluded segment could not be crossed using coronary guidewires due to its length (Panel A), therefore we had to use a radiofrequency catheter (Nikannen) (Panel B, C) to penetrate the occluded segment, given its length (approximately 20 mm); once this had been accomplished, the distal portion of the guidewire was snared with a loop catheter (Amplatz Goose Neck), and exteriorized by way of a radial-femoral "monorail" (Panel D).

Once the radial-femoral monorail had been established, dilatation was performed progressively with 1-mm to 4-mm-balloons (Panel E) to achieve distal flow; at that moment, an Amplatz extra-stiff guidewire was introduced via the femoral access, to continue the dilatation with larger-caliber balloons (BALT 8-10 mm) (Panel F). Finally, a covered stent, which was mounted on a balloon (NuMED Z-Med or BIB balloon) with a diameter similar to that of the aorta, was implanted at the level of the subclavian artery (Panel G). Then, the distal portion of the stent was post-dilated using a larger-caliber balloon to achieve correct apposition (Panel H). The results were confirmed both angiographically and hemodynamically (Panel I).

In our experience, totally occluded CoA represents 4% of the total number of percutaneous interventions in CoA and 12% of cases involving stent implantation. The collateral circulation is usually highly developed,



which confers special surgical difficulty and risk on the procedure. This has led to the development of the percutaneous approach, with techniques for crossing the occluded segment using coronary angioplasty or radiofrequency guidewires (in cases of long occluded segments) and implantation of a stent, which should preferably be covered with ePTFE. (3)

The use of ePTFE-covered stents can be recommended in this type of complex intervention in calcified aortas with a loss of structure due to medial cystic necrosis, which can progress to the formation of aneurysms, dissections, or even rupture. The stent should be positioned correctly in the wall with its ePTFE covering in order to reduce the incidence of complications. (4,5)

In experienced centers, percutaneous treatment of aortic atresia could be done with high rate of success and low rate of complications. The occlusion could be crossed in most cases with coronary guidewire, but in long ones, radiofrequency preferred. PTFE covered stents have better outcomes than standard stents because of providing a complete isolation of the aortic wall.

Conflicts of interest

None declared.

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