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Research Article

Developing New Skills for Smaller and Hidden Incisions

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Abstract

Background: Minimally invasive cardiac surgery has grown in adult population. However, its application to congenital heart disease in pediatric patients remains limited. In this scenario, alternative minimally invasive approaches have been recently used, but taking a step forward on a video-assisted repair is still unclear. We present the initial experience of a pioneering training animal model program for video-assisted repair in congenital heart defects and new tools for peripheral cannulation.

Methods: Phase 1. The ovine model

8 sheep was used for training the pediatric cardiac surgeons under the supervision of expert endoscopic surgeons.

Phase 2. Patients

2 pediatric pacientes with ASD underwent video-assisted repair (aditional port) by submammary and axillary regular approaches.

New skills for peripheral cannulation were developed: Echo assessment of femoral diameter and percutaneous stitching.

Results: 22 patients were enrolled after training in thoracoscopic assistance and peripheral cannulation for cardiopulonary by-pass (mainly ostium secundum atrial septal defects closure). Two patients had their original incision enlarged from 4 to 6 cm. Two complications requiring fasciotomy were recorded.

Conclusions: Although the small size of pediatric patients constitutes the main limiting factor for a video-assisted repair, the use of animal models for training in these techniques may be useful. Whereas familiar to surgeons, peripheral cannulation risks cannot be understimated. This training in close partnership with expert pediatric surgeons in thoracoscopic techniques and cardiologists used to percutaneous access is a key point for developing novel surgical skills for those commited to congenital heart defects.

BACKGROUND

Minimally invasive cardiac surgery has grown in adult population, with mitral surgery as a paradigm [1,2]. However, its application to congenital heart disease in pediatric patients remains limited, mainly because size constraints [3,4]. In this setting, alternative minimally invasive approaches have been recently used (sub-mammary, axillary, mini-sternotomy, etc.), but swapping from a single alternative approach to a multi-port one deserves learning new skills [5]. Along with peripheral cannulation (well-known strategy in redo procedures) taking a step forward on a video-assisted repair is still unclear in smaller babies [6]. We present the initial experience of a pioneering training animal model program for video-assisted repair in congenital heart defects in pediatric patients, as well as subtle changes in our routine practice for femoral cannulation, stressing mentorship in non-skilled areas.

MATERIAL AND METHODS

Starting from scratch, our goal is to organize a training program. Then, if appropriate, teaching and encouraging others to take similar paths.

Videothoracoscopic assistance

After a basic training in endoscopic tools (dry lab), a customized 30-40 Kg. ovine model was used under the proctorship of thoracic surgeons with vast endoscopic experience. Four congenital heart surgeons operated on eight sheep, supervised by a mentor (Figure 1). Three working ports for camera (0º & 30º angled; KarlStorz material) and surgical tools were created. Pericardial opening, superior and inferior vena cava dissection and aorta handling were performed in vivo. Creation of an atrial septal defect and subsequent closure were accomplished post mortem.

Next step was to add a thoracoscopic port to an otherwise routine approach. A 9-year, 40 Kg. and another 4-year, 14 Kg. patients were chosen, being approached the former through a sub-mammary and the latter by an axillary incision, respectively.

Thus, regular central cannulation (either sub-mammary or axillary one) was followed by thoracoscopic aid in fixing the intracardiac defect.

Finally, a series of simple conditions (Ostium Secundum Atrial Septal Defect) approached by peripheral cannulation plus videothoracoscopic assistance was started [7], adding other cardiac defects on gaining experience.

Peripheral cannulation

Right femoral cutdown for open surgical cannulation of arterial and venous vessels was accomplished, as for a redo procedure. Distal perfusion was checked by near infra red spectroscopy (NIRS) [8]. Under echo guidance, an indwelling sheath was placed in the right jugular vein. After draping and upon sterile conditions, with Seldinger technique, the surgeon advanced a proper sized superior vena cava cannula. Meanwhile, a second surgeon opened the chest in the 4th intercostal space (sub-mammary groove in females) and placed additional ports for camera and aortic clamp in the mid-axillary line.

Patient nº 4 developed a compartmental syndrome, requiring fasciotomy in the postop. Several measures were implemented onwards.

1. Echo surveillance of femoral vessels diameter prior to surgical dissection. According to our own algorithm (Table 1), femoral cannulation was discarded if peripheral arterial size was not enough to accommodate the selected return cannula (then, an alternative surgical approach was chosen instead)
2. Percutaneous access to femoral vessels. Accordingly to jugular cannulation, sheaths for right venous and left arterial femoral lines were secured in place before draping. A cardiologist from the cath-lab proctored us in deploying and fastening a preloaded stitch system (two shots, ProGlide, Abbott) for the first three patients.

RESULTS

Table 2 resumes data of 22 consecutive patients approached with peripheral cannulation, thoracoscopic guidance and small working port (4-6 cm.). Patients with partial peripheral cannulation (mainly femoral vein) as an adjunct to sub-mammary or axillary approaches with central cannulation are not included in this report.

Rate male/female was 1:1. Mean age was 15.4 years (range 6-37), being 3 patients older than 18 years. Mean weight was 53 Kg. (range 23-81).

Table 1: Femoral artery diameter (echo estimated) and cannula size selection, according to Body Surface Area (BSA).

Echo Ø (mm)	Estimated size (x3)	French size cannula	BSA
5	15	15	<1.7
6	18	17	>1.7
7	21	19	>1.9

Most cases are simple defects, to start with, such as Ostium Secundum atrial septal defects (OS ASD). An Ostium Primum, a mitral regurgitation and a tricuspid regurgitation (in a former arterial switch operation for transposition of the great arteries, ASO/TGA) complete the chart. Cardioplegic arrest was used routinely for myocardial protection. Several patients had a fibrillary arrest lately in the series, at surgeon discretion.

Patients 5 and 12 had the small working port enlarged from 4 to 6 cm, to aid in exposure, (the latter -female- along the sub-mammary crease which was pre-drawn with a marking pen).

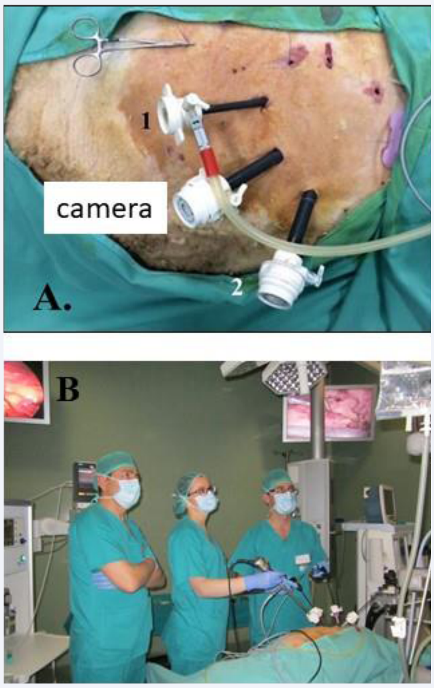

Figure 1 Training in animal model (sheep). Ports placement

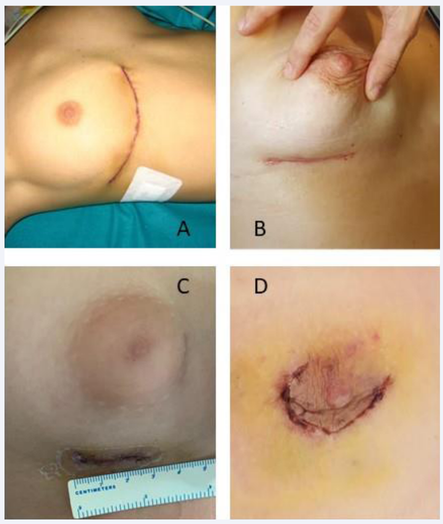

Figure 2 Sub-mammary incision, before (A) and after (B, C) peripheral cannulation and videoassistance training. Periareolar access in male (D).

Table 2: Patient data. F: induced ventricular fibrillation (alternative to cardiopegic arrest). OS ASD: Ostium Secundum Atrial Septal Defect.

Patient (nº)	Gender	Age (years)	Weight (Kg)	Diagnosis	Surgical Technique	ECC (minutes)	Clamp (minutes)	Follow-up / complications
1	male	12	36	OS ASD	suture	145	70	
2	male	13	46	OS ASD	patch	157	41	
3	male	12	23	OS ASD	patch	102	23	
4	female	10	50	OS ASD	suture	135	52	compartmental syndrome
5	male	12	47	OS ASD	suture	123	16	sub-mammary enlargement
6	male	18	75	OS ASD	suture	120	38	
7	male	6	29	OS ASD	suture	94	12	
8	female	14	55	OS ASD	patch	108	46	
9	female	9	46	OS ASD	suture	116	36	
10	female	15	42	Ostium Primum	cleft closure + patch	119	65	
11	female	16	58	OS ASD	patch	90	22	
12	female	16	52	Mitral regurgitation	plasty + ring	198	124	sub-mammary enlargement
13	male	14	60	OS ASD	patch (peri-areolar)	170	53	
14	male	11	57	OS ASD	patch (peri-areolar)	200	80	
15	female	14	45	OS ASD	suture	148	54	
16	female	12	60	OS ASD	patch	165	56	
17	female	20	68	OS ASD	patch	75	28 F	
18	male	12	52	OS ASD	patch (peri-areolar)	125	29	compartmental syndrome
19	male	37	81	OS ASD	patch (peri-areolar)	140	75	
20	male	18	62	Tricuspid regurgitation	ring	79	40 F	
21	female	16	58	OS ASD	suture	58	18 F	
22	female	32	65	OS ASD	patch	59	30 F	
Mean (range)		15.4 (6-37)	53 (23-81)			123.9 (58-200)	45.8 (12-124)	

As shown in Figure 2, we swap from a large sub-mammary incision (with central cannulation) to a smaller one with video assistance and peripheral cannulation. Our latest patients benefit of a 3-4 cm sub-mammary groove scar (females) or a peri-areolar approach (4 males). Should a bail-out conversion was required, the sub-mammary fold in its whole length was previously marked with 2 cm gap landmarks beforehand

Mean Extracorporeal Circulation Time (ECC) was 123.9 minutes (range 58-200). Mean ischemia (either cardioplegic arrest or induced ventricular fibrillation) was 45.8 minutes (range 12-124).

Two patients developed compartmental syndrome. The complication rate was 2/22 = 9% (95% confidence interval: 1-29%). The confidence interval was calculated using the exact binomial Clopper-Pearson method. Obviously, due to the small sample size the confidence interval is rather wide, but reveals an upper limit of 29%. Case nº 4, as previously stated, who prompted us to implement additional caution strategies. Of note, NIRS was fine along surgery. Special attention deserves patient nº 18, in whom a displacement of a third spare ProGlide stitch at the end of the surgical procedure (with immediate NIRS step-down) prompted us to an open surgical revision of the left femoral artery. The percutaneous device happened to impinge both anterior and posterior vessel walls, needing a patch repair of the femoral artery in situ. A compartmental syndrome appeared, eventually, in spite of expeditious ischemia relief.

DISCUSSION

In the quest of smaller or hidden incisions and keeping safety, we and others [3,4,5,9] travel from full midline sternotomy to lower partial sternotomy, sub-mammary and axillary approaches. There are several large samples reports from experienced centers which describe minimal invasive approach by anterolateral thoracothomy with no port access and small incisions. These alternative incisions share to be single ones, allowing cannulation and fixing of the defect through the same port (not necessarily small). Stepwise changes are advisable as stated by some authors [1] so as to make anyone in theatre feel comfortable with innovation. Mirroring mitral surgery in adults, endoscopic (and, eventually, robotic) surgery should follow next.

Congenital cardiac surgeons are not familiar with endoscopic procedures and, excepting redo surgery, femoral cannulation is not frequently required. Confidence on our own baggage may be misleading if we are not aware of basic skills needing. Looking for training models and proctorship was our first command, before starting an endoscopic program [10,11]. We forecast longer operating, extracorporeal and ischemic times, altogether [9]; assuming a conversion rate [5] to a former conventional incision (sub-mammary, mainly, rather than midline sternotomy).

Training with a proctorship was of paramount importance. A three step in thoracoscopic skills proved successful in our group (animal model, large incisions and small incisions). Insertion of cannulae after diameter echo assessment became routine, rather than "eye-balling" election of lines size. Percutaneous devices for bleeding control worked fine for seroma prevention [12] and fast recovery, again proctored by a specialist from the cath-lab. Unfortunately, a shooting mistake in one patient ended in a compartmental syndrome.

Limb ischemia after peripheral cannulation has been documented in adults, but seldom in children [13]. One should keep in mind that left-to-right shunts (as in OS ASD) render the arterial tree smaller that expected (unlike mitral surgery, in adults). Thus, femoral arteries in children with OS ASD might appear thinner than average and become somehow undersized for longer extracorporeal times. Beware of drawbacks in two patients, we adhere strictly to proper size cannulae selection according to artery diameter and do not hesitate to discard peripheral cannulation. Graft interposition or reverse flow cannulae can aid in preventing femoral artery compromise.

Not only thoracoscopic skills have aid in expanding our selection in extracorporeal approaches for simple intracardiac defects. As an adjunct, some patients with arrhythmia have benefited from minimally invasive tolos [14,15].

The periareaolar access in men and small (4 cm) submammary crease approach in women are the ones pursued with this thoracoscopic approach, in a step by step learning curve.

CONCLUSIONS

1. Minimally invasive approaches for simple defects in congenital cardiac surgery are evolving, following similar trends than adults.
2. Background in alternative approaches to midline sternotomy is advisable before taking smaller and/or hidden incisions.
3. New tools, like endoscopic assistance, need to be learnt and mastered by dedicated proctorship and training models.
4. Old techniques, such as peripheral cannulation, cannot be underestimated. Smaller femoral vessels in left-to-right shunts may jeopardize limb function in long extracorporeal times.
5. Conversion rate to known incisions (sub-mammary) and central cannulation should be regarded with a low threshold.

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