Cardiopulmonary endoscopy: an effective and low risk method of examining the cardiopulmonary system during cardiac surgery

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Abstract

Objectives: During cardiac surgery it is sometimes necessary to examine heart chambers remote from the site of surgery. Similarly visualization of the pulmonary arterial tree will enable assessment for the completeness of pulmonary embolectomy. There are no standard adjunctive procedures to accomplish this. Left ventriculotomy used to examine the left ventricle, and maneuvers used to ensure complete pulmonary embolectomy can have serious complications. Impelled by the need to obviate the complications, we adopted and, herein describe a simple method of examining the cardiopulmonary system with an endoscope. Our early experience is also presented.

Method: Transmitral cardioscopy was performed in two patients, and pulmonary angioscopy in one. One patient had the combined procedure. The indications for transmitral cardioscopy were; suspected left ventricular thrombus and a right atrial thrombus propagating into the left atrium through a patent foramen ovale. The indications for pulmonary angioscopy were pulmonary embolectomy and right atrial thrombus.

Surgical technique: Cardiopulmonary endoscopy was performed on cardiopulmonary bypass, at an appropriate stage of the primary procedure. For transmitral cardioscopy, a flexible fibreoptic endoscope was passed into the left ventricle through the right superior pulmonary vein, or the right atrium. For pulmonary endoscopy, the flexible endoscope was introduced through a pulmonary arteriotomy. At the end of the procedure, the port of entry of the endoscope was closed and cardiopulmonary bypass terminated.

Results: A good visualization of the cardiac chambers and the pulmonary artery was obtained in all the patients. One patient was found to have an endocardial scarring, and a left ventricular thrombus was excluded in another. Visual guidance facilitated pulmonary emboli retrieval. There were no complications in these patients.

Conclusion: Cardiopulmonary endoscopy is simple, safe and effective in examining the cardiac chambers and the pulmonary arterial system. It can be performed with a sterilized flexible fibreoptic endoscope. It facilitates pulmonary embolectomy, and precludes procedures and maneuvers that can cause serious complications. It adds a visual advantage to pulmonary embolectomy, which is otherwise blind. Cardiopulmonary endoscopy has the potential for a wider applicability, possibly in minimally invasive and robotic cardiac surgery.

Keywords: Transmitral cardioscopy; Pulmonary angioscopy; Cardiopulmonary endoscopy

1. Introduction

Endoscopic surgery has brought about monumental changes in abdominal and thoracic surgery. Unfortunately, it has not had a similar impact in cardiovascular surgery because of problems with visualization. Since the development of the first cardioscope by Rhea and Walker in 1913 [1], several attempts have been made at designing the 'ideal' cardioscope [2–4]. As a result, the history of cardioscopic surgery is characterised by repeated failures and abandonment by the few who dared. Recently there has been a revival of interest in cardioscopic surgery, but there is uncertainty about its place in the management of patients [5–7]. Although it is still experimental, its diagnostic as well as, therapeutic capabilities are beginning to emerge [8–14].

There are few reports of the adjunctive use of pulmonary angioscopy with pulmonary embolectomy [15–17], but the potential benefits of this procedure have not been explored.

During cardiac surgery it is sometimes necessary to examine heart chambers remote from the site of surgery. Similarly, visualization of the pulmonary artery tree during pulmonary embolectomy will enable assessment of the efficiency of the procedure. There are no standard adjunctive procedures to accomplish this. Even though this scenario is not common in clinical practice, the procedures usually adopted to evaluate suspected intracardiac pathology or ensure complete pulmonary embolectomy, can cause serious complications. Ancillary procedures that would enable an effective examination of the cardiopulmonary...
system without adversely affecting outcome in patients are therefore needed.

Left ventriculotomy has been shown to inflict adverse functional consequences on the left ventricle, especially in the presence of an impaired left ventricular function [18]. Also squeezing the lungs and overenthusiastic use of retrieval forceps during pulmonary embolectomy, can have life-threatening complications [19,20].

The need to obviate these complications impelled us to perform transmitial cardioscopy and pulmonary angioscopy as adjunctive procedures in our patients.

We describe our method of cardiopulmonary endoscopy using an ordinary flexible fiberoptic endoscope, and present our early experience.

2. Patients and methods

The cardiopulmonary procedures performed were transmitial cardioscopy (TMC) and pulmonary angioscopy. These procedures were carried out by a single surgeon, in patients referred for cardiac surgery. Depending on their primary cardiopulmonary pathologies, they were investigated by various imaging techniques, including chest radiograph, transthoracic and transoesophageal echocardiography (TOE), spiral CT scan, cardiac catheterisation, and ventilation-perfusion scan.

The indications for TMC were; suspicion of a left ventricle (LV) thrombus, and a right atrial thromboembolus propagating into the left atrium through a patent foramen ovale. Pulmonary embolism and the presence of a serpiginous thromboembolus in the right atrium were the indications for pulmonary angioscopy.

We used a Fujinon upper gastrointestinal electronic video endoscope (EG-401HR type S) with a forward viewing lens, a 1.5× magnification and 120° field of vision, manufactured by Fuji Photo Optical Co. Ltd. (Japan). The distal end of the flexible fiberoptic endoscope has a forceps channel, an air/water nozzle, a light guide and an image guide. The endoscope is sterilized by immersion. For the sterilization process, water is pre-softened and filtered to 0.2 microns in order to remove all environmental contaminants. It is mixed with lancerzyme, an enzymatic detergent. The endoscope is then washed in this solution and all the channels are brushed three times. The endoscope is rinsed with fresh filtered water and then immersed in 0.26% peracetic acid, in an automatic endoscope disinfector. All the channels are filled with sterilent and soaked for 10 min, before two cycles of rinsing with filtered water ensures the removal of the chemicals.

2.1. Surgical technique

A radial arterial line for invasive blood pressure monitoring was inserted while the patient was being preoxygenated. Anaesthesia was induced with intravenous propofol, intravenous muscle relaxant given and the patient intubated. A central venous line was placed and a TOE probe positioned. After skin preparation and draping, a median sternotomy was performed and cardiopulmonary bypass instituted using a single atrial drainage cannula and an aortic return cannula. A left atrial (LA) vent was introduced through the left superior pulmonary vein, the aorta cross-clamped and cardioplegic arrest achieved with antegrade blood cardioplegia. The primary procedure was performed and at an appropriate stage, TMC and/or pulmonary angioscopy were carried out. TMC was performed after the bottom-end anastomoses in CABG patients, and pulmonary angioscopy was done after pulmonary embolectomy.

TMC was performed by, replacing the LA vent with the flexible fiberoptic endoscope. The blood in the LA was displaced with air to allow visualization of the chamber. The flexible fiberoptic endoscope was then maneuvered into the left ventricle and the entire chamber examined (Fig. 1), using the proximal control knobs. At the end of the procedure, suction was applied through the endoscope to remove the air before withdrawing it. De-airing was continued through an aortic root vent under the monitor of the TOE.

For pulmonary angioscopy, the same endoscope was introduced through the main pulmonary arteriotomy, and manipulated under vision into the branches. By displacing air and applying suction it was possible to visualize the pulmonary arterial tree up to the tertiary branches. A guided retrieval of emboli using a Desjardin or biopsy forceps was then possible. After a satisfactory exploration the endoscope was removed and the arteriotomy closed.

The rest of the primary operation was concluded as usual.

3. Results

Two patients had TMC and one patient had pulmonary angioscopy. Combined TMC and pulmonary angioscopy was performed in one patient. The visualization of the cardiac chambers was excellent with TMC. The intracardiac anatomy was well demonstrated. No LV thrombus was seen but an area of endocardial scarring was obvious in one patient. During pulmonary angioscopy, the endoscope required to be cleaned twice to obtain a good visualization of the tertiary branches of the pulmonary artery on each side. Pulmonary angioscopy facilitated emboli removal and enabled an assessment for the completeness of pulmonary embolectomy.

De-airing the heart was easily accomplished. There was no complication or mortality in these patients.

4. Discussion

Intraoperative adjunctive procedures during cardiac surgery can adversely affect the outcome of surgery. Left ventriculotomy to explore for an intracardiac pathology, and squeezing the lungs or an overzealous use of retrieval instru-
ments, in an attempt to achieve complete pulmonary embo-
lectomy have been reported to be detrimental to the surgical out-
come [18–20]. Cardiopulmonary endoscopy magnifies
the true image, and clearly displays the anatomy in fine
details. More so, video projection enabled better demonstra-
tion for teaching and photographic documentation. As the
‘ideal’ cardioscope that will overcome the problem of visual-
ization through blood is not yet widely available, various
reports of cardioscopic surgery have used different locally
designed cardioscopes [5,8,9,21]. Our adaptation of an
upper gastrointestinal video endoscope for cardiopulmonary
endoscopy shows that this procedure can be performed with
good results in many centres where ordinary flexible
fiberoptic endoscopes are available. Beckman et al. [15],
and Morshius et al. [16] used a flexible choleodochoscope
to perform a pulmonary angioscopy successfully. The
various channels at the distal end of the flexible fiberoptic
endoscope allowed us to perform these procedures success-
fully. The channel for air/water was used to achieve the
displacement of blood with air during the procedure so
that a good view was obtained, and applying suction further
helped to improve visualization. Our preference for using
air, instead of normal saline was because the heart is less
likely to be distended to the extent of jeopardizing myocar-
dial protection with air. Complete de-airing of the heart was
easily achieved using the suction through the endoscope and
aortic root vent, under the TOE monitor.
Cardiopulmonary endoscopy using a flexible fiberoptic
endoscope is a less traumatic adjunctive procedure, but
the therapeutic potential is inferior to that of rigid endo-
scopes. For TMC, the flexible fiberoptic endoscope crosses
the mitral valve in a direction that is prograde to blood flow
and therefore physiological. It also avoids the aorta that can
be atherosclerotic in this patient population, thereby reduc-
ning the risk of embolic phenomenon.
Pulmonary embolectomy is a blind procedure, but yields
a satisfactory outcome in patients with massive pulmonary
embolism [22–25]. This life-saving procedure can be com-
licated by a life-threatening, haemorrhage [19,20],
resulting from pulmonary artery injury inflicted by maneu-
vers to achieve complete embolectomy. Also incomplete
pulmonary embolectomy can cause prolonged morbidity.
Pulmonary angioscopy completely changes the status of
this operation by lending a visual advantage to it. It facil-
itates pulmonary embolectomy by guiding emboli extrac-
tion under vision, and thereby eliminating the grave risk of
pulmonary artery injury. Should pulmonary artery injury
occur, it allows localization and evaluation of the severity,
with a view to planning appropriate treatment. Importantly, the completeness of embolectomy can be assessed. Beckman et al. [15] found residual emboli at pulmonary angioscopy in two out of three patients following pulmonary embolectomy.

Adequate sterilization of the endoscope is of utmost importance. We did not have any infective complication in our patients.

The clinical situations where these procedures are required are not very common and this accounts for the small number of patients in the study. However, it has potentials for a wider applicability, particularly in minimally invasive and robotic cardiac surgery.

Cardiopulmonary endoscopy is a budding area of cardiac surgery that needs to be explored. We have found it to be a useful adjunctive method of evaluating the cardiopulmonary system during cardiac surgery with no morbidity. It is safe and simple, and can be performed effectively using a sterilized ordinary flexible fibreoptic endoscope. It has potentials for use with minimally invasive and robotic cardiac surgery.

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References