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METHODS

Experimental Validation of Videoendoscopic Isolation and Occlusion of the Bloodflow in Open Ductus Arteriosus

Yu. V. Vasilenko, A. I. Kim*, and S. A. Kotov*

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The potentialities of videoendoscopic isolation and extravasal occlusion of large vessels with titanium clips were studied in acute and chronic experiments on 36 animals and anatomic studies on 5 human cadavers. The number and optimal sites for insertion of trocars and disposition of instruments and thoracoscope for isolation of open ductus arteriosus were determined. A method for videoendoscopic isolation of vessels is developed and possible complications and measures for their liquidation evaluated. High efficiency and low traumatism of videoendoscopic operation are proven under condition of strict adherence to methodology and sufficient qualification of the surgeon in endosurgical manipulations.

Key Words: *open ductus arteriosus; videothoracoscopy; extravasal occlusion; clipping*

Videothoracoscopic (VT) occlusion of the bloodflow in open ductus arteriosus (ODA) is used in congenital heart disease. The advantages of the new operation are low mortality, alleviation of the postoperative painful syndrome, and improvement of lung function due to minimum traumatism of the access, decrease of the risk of intraoperative hemorrhages, reliability of bloodflow occlusion, shorter duration of hospital treatment and rehabilitation of patients, and lower cost of treatment [2-6,8].

However, such interventions are associated with laryngeal recurrent nerve injury (2.2-5.9% cases), pneumothorax (1.7-2.2%), chylothorax (0.4-4.4%), residual bloodflow (2.1%), and transfer to thoracotomy 8.7-13%) [2-4]. Most complications are explained by the absence of a universal method of the operation and necessary instruments, clear-cut definition of indications and contraindications for endoscopic intervention, and measures for prevention and liquidation of complications.

Specific complications are the follows: vessel injuries with the development of hemorrhages, nerve injuries, lymph vessel injuries with subsequent lymphorrhea, lung tissue injuries with development of pneumo- and hemothorax, arrhythmias, myocardial injury, and asystole. The aim of this study was to determine the optimal sites for insertion of trocars and to study specific features of videoendoscopic (VE) method for isolation and extravasal occlusion of ODA with titanium clips.

MATERIALS AND METHODS

The method of VT intervention on ODA was mastered in acute and chronic experiments on 30 mongrel dogs of both sexes (10-37 kg) without adhering to the chronobiological factor, on 6 swine (8-30 kg), and 5 unfixed human cadavers.

For premedication and introduction narcosis the animals were intramuscularly injected with 10 mg/kg ketamine, 0.25 mg/kg droperidol, and 0.2 ml atropine. The animals were lying on the right side in position for standard left-side thoracotomy. Basic narcosis was carried out by intravenous fractionated injections of

Russian State Medical University, Moscow; *A. N. Bakulev Research Center of Cardiovascular Surgery, Moscow

2.5% hexenal (or sodium thiopental) in a dose of 10-15 mg/kg. Heart rate and heart rhythm were monitored by ECG in standard leads. Controlled artificial ventilation was carried out using RO-6 and Draeger devices in the moderate hyperventilation regimens. The animals were sacrificed by intravenous injection of ketamine in a dose of 100 mg/kg or air embolism (50-70 ml).

In the first series of acute experiment (5 dogs) VE technique was combined with minithoracotomy. The optimal access to the operation field was developed by combining 3 thoracoports in different intercostal spaces, starting from the scapular angle to the VI-VII intercostal space. During the experiment video-assisted thoracoscope and the instruments changed places or the position of thoracoscope in the thoracotomic incision was changed.

During the second series of experiment (20 dogs and 6 swine) the intervention was carried out by VT using 3 trocars without thoracotomy. During stage 1 the pleural cavity was punctured with Veresche needle and pneumothorax was created without forced injection of air into the pleural cavity. The first thoracoport and 4-mm thoracoscope were inserted. At stage 2 instrumental trocars were inserted under visual control. At stage 3 VT isolation of vessels and their extravasal occlusion were carried out. The left subclavian artery served as the main ODA model, the left internal thoracic artery, descending part of aortic arch, and pulmonary trunk served as additional models. After isolation the left subclavian artery and left internal thoracic artery were subjected to extravasal occlusion by clipping with titanium clips of appropriate size and subsequent crossing between the clips. The descending part of aortic arch and pulmonary trunk were mobilized circularly with subsequent ligature.

In chronic experiments on 5 dog (VE with 3 trocars) isolated left subclavian artery was clipped with 2 titanium clips. Pneumothorax was liquidated and the postoperative wounds were sutured layer-by-layer. After 1, 2, 3, and 4 weeks VE was repeated. The efficiency of clipping was evaluated and the vessels between the clips were crossed, after which acute experiment was carried out.

In order to choose the optimal points for trocar insertion and positions of the instruments with respect to the aortic arch in humans, experiments were carried out on 5 human cadavers. Trocars were inserted in various points of the III and IV intercostal areas.

Equipment and instruments from K. Storz, Rema, Aksioma firms, allowed for use by the Ministry of Health of the Russian Federation, were used in the study.

RESULTS

The position of the instruments and thoracoscope was evaluated by the following criteria: adequate illumination and size of visible field, possibility of free manipulations and full-value functioning of instruments, atraumatism of manipulations, and convenience of surgeon's and assistants' work.

Experiments showed that the IV intercostal space along the armpit line and 1 cm more backwards, depending on the length of the intercostal space, was the optimal position of thoracoscope for pneumothorax, insertion of the 1st trocar, and diagnostic thoracoscopy.

The optimal zone for placing the 2nd trocar (5-mm) for lung retractor is the III intercostal space along the anterior armpit line or 1 cm forward from it. The 3rd trocar (instrumental) is to be situated in the III intercostal space along the posterior armpit line or 1 cm backward from it.

During isolation and extravasal occlusion of ODA the thoracoscope should be transferred into the 3rd trocar and the instruments be delivered through the 1st trocar.

Anatomical variants of the large vessels development, high or low position of the aortic arch or ODA, concomitant diseases impeding the manipulations can create situations when additional instruments have to be introduced through the 4th trocar in a point 1 cm towards the median from the anterior armpit line in the IV intercostal space or 2-4-cm minithoracotomy has to be made in the III intercostal space.

A 5-mm endoscopic retractor with bent rhomboid branches connected with each other (Aksioma Firm) is a convenient, reliable, and atraumatic instrument for lung retraction. A serious deficiency of models of other firms is poor fixation of lung tissues, leading to frequent squeezing and spreading of the lung thus closing the operative area; as a rule, this happens rapidly and suddenly, which can lead to complications and prolongs the duration of adequate retraction of the lung 4-fold.

Tissue preparation and dissection should be either simultaneous with electrocoagulation or be preceded by it. The optimal variant is a standard L-shaped electrode 5.0 or 3.7 mm in diameter, ensuring convenient and safe precision preparation, coagulation, and dissection of tissues. Use of an electrode with rounded working part is fraught with electric injury to the adjacent tissues by the protruding back edge of the electrode even in case of thorough preparation of tissues,

However, during isolation of vascular walls the possibility of using L-shaped electrode was limited by the depth of no more than 5-7 mm, which minimized the working space and deteriorated visual control in the depth of the forming cavity. Under such conditions it is recommended to proceed with tissue preparation using a dissector with bent branches and a palpation probe with a round apex. Successive use of these in-

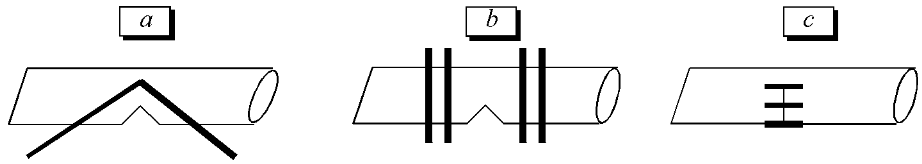

Fig. 1. Methods for videoendoscopic arrest of hemorrhage. *a*) clipping of the damaged site of vascular wall parietally or with complete occlusion of the vascular lumen as the first and only stage; *b*) temporary clamping of the vessel with subsequent final hemostasis by endoscopic methods; *c*) temporary clamping of the vessel with a clamp with subsequent thoracotomy and final hemostasis by clipping, ligation, or suturing.

struments allows sufficiently complete dissection of paravasal fat from three sides of the vessel without making the intervention more traumatic. Complete circular isolation of vessels in VE can be attained using bent flexible ribbon-like dissectors (Storz).

If our method is strictly adhered to, the VE isolation of large cardiac vessels does not lead to specific complications, except isolation of the right pulmonary artery and pulmonary trunk. Attempts at circular isolation of these vessels led to hemorrhages of different intensity in almost half the cases; the hemorrhages could not be arrested by purely endoscopic method and eventuated in asystole. These complications confirmed the opinion of the majority of authors about the hazards of isolation of the posterior semicircle without visual control.

In order to develop methods for liquidation of intraoperative complications of a VE intervention, we studied the potentialities of endoscopic method in arrest of intrapleural hemorrhages from large vessels (Fig. 1). Bleedings were induced by instrumental injuries (up to 1.0-1.5 mm in diameter) in the anterior, lateral, and posterior vascular walls in succession.

Parietal endoscopic clipping of a bleeding vessel was ineffective. Bleeding from the left subclavian artery can be effectively arrested by the endoscopic method if the injury is located on the anterior wall of the vessel. If the bleeding is located on the lateral wall, bleeding can be arrested in half the cases. The final homeostasis can be attained by temporary clamping of the vessel, thoracotomy, clipping or ligation of the vessel and suturing. Injury to the posterior wall requires urgent thoracotomy in all cases. Bleeding from the aorta and pulmonary artery can be temporarily arrested by clamping in all the cases. The final hemostasis can be attained through the thoracotomic access.

The arteries (3-6 mm in diameter) of animals were subjected to extravasal occlusion by compression with 2 titanium clips of appropriate size. After crossing of arteries between the clips no bleeding was observed in any of the cases, which indicates the efficiency of this method of bloodflow arrest. The results were confirmed in a chronic experiment. We observed no complications associated with VE isolation of vessels and their extravasal occlusion by clipping neither during the immediate nor during delayed postoperative period (1 month after the intervention). Moderate suppuration of the postoperative wound was observed in one experimental animal.

Moderately expressed adhesive process without infiltrative changes in adjacent tissues was observed round the clipped vessel. The clips were positioned properly (strictly perpendicular to the longitudinal axis of the vessel) in all cases.

From these data we conclude that VE isolation and clipping of large (3-6 mm) vessels is a safe and reliable intervention on condition the methodological principles are strictly adhered to, certain instruments are used, and the surgeon is experienced in VE methods.

VE isolation of the posterior wall of the pulmonary artery or pulmonary trunk is associated with development of uncontrolled bleeding, which is a life-threatening condition precluding the use of endoscopic method in such interventions. Bleeding from the anterior or one of the lateral walls of mobilized vessels can be rapidly and effectively arrested by the endoscopic method.

Defects in the anterior and lateral walls of the aorta and pulmonary artery and the bleeding caused by these injuries can be temporarily arrested by the endoscopic method and finally arrested by traditional suturing of vascular wall through the thoracotomic access.

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