Extravasal Occlusion of Large Vessels with Titanic Clips: Efficiency, Indications, and Contraindications

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The mechanism of extravasal occlusion of blood vessels with titanic clips "Atrauclip" and "Ligaclip extra" was studied in order to reveal indications and contraindications to their use. Occlusion with the clips of both types was ineffective in vessels with a diameter of >7.0 mm. Arteritis or the presence of an intravascular occlusion facility in the vessel were also the contraindications for clip occlusion. In overcases the procedure of occlusion with titanic clips was efficient and atraumatic.

Key Words: *extravasal occlusion; patent arterial duct; titanic clips; vessel diameter; efficiency; traumatis*

Ligation of arterial duct (PAD) after left posterolateral thoracotomy is a simple and comparatively safe method, which yields reliable results, although it is characterized by very high incidence of postoperative lethality (up to 2%) and recanalization of the duct (0.4-23.0%) [1,2,4,6,7,9,10].

Metal clips are widely used to arrest the blood flow in PAD both during thoracotomy and videoimage endoscopy. In comparison with PAD ligation, the advantages of PAD clipping are low incidence of traumatism or complications, and reliability, simplicity, and execution quickness. However, this surgery intervention is accompanied by residual blood flow (2.1% cases) and dysfunction of recurrent laryngeal nerve (2.2-5.9% cases), which explains the current diversity of opinions about this method, indications, and contraindications to use the clips in dependence on their type, size, and diameter of PAD [3,5,7,8].

Our aim was to develop indications and contraindications to extravasal occlusion of PAD by its compression with titanic clips.

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MATERIALS AND METHODS

The mechanism of extravasal occlusion (EVO) with titanic clips was studied on freshly isolated canine (n=25) and porcine (n=6) arteries immediately after acute experiment designed to assess the potency of videoimage endoscopy to arrest blood flow in PAD.

Series I used vascular segments (n=30) with diameter 3, 5, and 7 mm. Each vessel was compressed in turn with Atrauclip (Pilling) and Ligaclip Extra (Ethicon) clamp of corresponding diameter and ligated with Prolen No. 5 (in total, 90 observations). The process of EVO was monitored with intra- and extravasal video filming apparatus (K. Storz).

In series II, the efficiency and the absence of traumatism of EVO performed with titanic clips were assessed. The specimens were: 1) clipped arteries isolated from the animals and corpses and then fixed in 10% formalin (n=60) and 2) human varicose veins (n=60) examined 1-3 h after phlebectomy.

The clipped vessels with diameters of 3, 4, 5, 6, 7, and 8 mm were subjected to static and dynamic intravascular pneumatic hypertension (SIPH and DIPH, correspondingly) modeled in vascular hypertension apparatus made of hermetic tubes with the stop-cocks, syringe, manometer, and elastic latex chamber. The

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vessels were hermetically connected to the apparatus and immersed into water. At the first stage, SIPH was performed, which applied constant intravascular pressure of 480 mm Hg for 30 min in each specimen. At the second stage, each vessel was subjected to DIPH at the rate of 80-100 pulses per minute for 30 min, which imitated pulse pressure with the amplitude of 120-200 mm Hg. DIPH was performed by periodic compression of elastic chamber with a manometer-controlled pressure. The appearance of air bubbles in the occlusion area indicated incompetence of the vascular wall. Air leakage from the distal segment of the occluded vessel attested to insufficient occlusion without impairment of vascular wall integrity.

RESULTS

After ligation the vascular wall looked corrugated due to invaginations of internal layers into the lumen and deformations of its external layers. Thread tension during ligation is subjectively controlled by the surgeon on the basis of personal experience. Insufficient tension during ligation leads to incomplete occlusion of the vascular lumen and restoration of the blood flow in PAD both in early and late periods after EVO performed by vascular ligation. By contrast, overstretched suture can damage the vascular wall, which is extremely dangerous in large vessels or vessels with thickened and infiltrated wall [1-3,5,7,8].

Extravasal occlusion with clips has no such disadvantages, because vascular walls are strictly parallel and not deformed. Extravasal occlusion with a clip proceeds in two stages: first, the tips of the clips are closed under the action of clip-applicator branches, and second, the branches are straightened out under the increasing pressure and close along the entire length. If the size of clip does not match the vessel, the tips of the closed clip either lie on the vessel wall and can damage it or do not close the lumen completely thus preserving pathological blood flow.

Measurements of clip length in the state of perfect and imperfect closing showed that the maximum difference of these values is 0.3 mm. Therefore, when choosing a clip size, one should take into account the lengths of both partially and completely closed clip.

Our method is based on comparison of the length of the closed clip and the width of blood vessel compressed between two parallel planes. Taking into account the stages of clip closing, the necessary clip length (in mm) was calculated by the formula:

$$L=3.14\times d/2+0.3,$$

where $3.14\times d/2$ is width of flattened vessel, d — external diameter of the vessel, 0.3 — a coefficient accounting for peculiarity of clip closing.

Calculations showed that one of the contraindications for EVO with titanic clips is too large (>7 mm) external diameter of the vessel. However, one of the basic features of EVO is its reliability and atraumatic character. In the second series of experiments, SIPH test showed that irrespective of vascular diameter, occlusion was adequate in all cases. By contrast, DIPH test revealed that in almost half cases occlusion of arteries and varicose veins with a diameter of 7-8 mm was inadequate due to partial sliding of the clip without visible damage to the vascular wall.

EVO performed with the clips of both types was inefficient, when vascular diameter surpassed 7 mm. Sliding of the clips from the vessels determined inadequate occlusion, which probably was caused by insufficient resistance of the clips to the opening force and by imperfection of the shape of their internal surface.

These data confirmed efficiecy and atraumatic character of EVO performed with titanic clips. The contraindications to this method of occlusion are large diameter of the vessels (>7 mm), the presence of intravascular occlusion facility, and arteritis. The choice of the clip size depends on external diameter of the blood vessel, while the mechanism of clip closing and reliability of its fixation on the vascular wall should also be taken into account.

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