AORTIC VALVE REPLACEMENT VIA RIGHT THORACOTOMY

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Currently, conventional and hemi-sternotomy (J sternotomy) approaches are widely used in surgery for isolated aortic valve diseases (stenosis, insufficiency, etc.). With the emergence and widespread use of transcatheter aortic valve implantation (TAVI), the development of minimally invasive surgical techniques has gained importance. Minimally invasive aortic valve replacement (AVR) via right anterior thoracotomy (RAT) (Mi-AVR-RAT) is a technique that developed over the last decade. This procedure is more challenging than conventional aortic valve surgery due to limited visibility of the anatomical structures. Several published studies comparing AVR via RAT and/or upper ministernotomy versus full sternotomy report longer cardiopulmonary bypass (CPB) and cross-clamp times with non-traditional approaches. Prospective randomized studies have demonstrated the advantages of the minimally invasive approach in terms of reduced bleeding, postoperative pain and trauma, shorter hospital and intensive care unit (ICU) stays, and consequently reduced costs.

TECHNIQUE

Before surgery, diagnostic coronary angiography (if indicated), transthoracic echocardiography, and anteroposterior and lateral thoracic X-rays are required. Contrast-enhanced thoracoabdominal peripheral computed tomography (CT) is an indispensable imaging method in the planning of surgery and the indication of the procedure.

Anatomical criteria:

The position of the ascending aorta at the level of the pulmonary artery bifurcation:

1. The proximity of the aorta from the sternum to the right thorax wall is to be over 50%
2. The distance between the ascending aorta and the sternum should be less than 10 cm
3. Alpha angle >45°

These criteria are the basic conditions in our surgical planning with RAT. As procedure experience increases, small changes in these conditions can be made on a patient-by-patient basis.

The patient is placed in supine position and an inflatable bag is placed under the right scapula to tilt the rib cage to the left side. External defibrator pads are placed in the appropriate part of the back. Double lumen intubation is provided to prevent the right lung from obstructing vision (Photo 12.1, Figure 12.1).

A skin incision of approximately 5 cm is made following the third costal line. At the beginning of the learning curve, the incision can be enlarged up to 7 to 8 cm. The right internal thoracic artery and vein are explored, ligated and/or clipped and cut. The second or third right intercostal space is opened, avoiding rib damage. This method can be used to determine the correct intercostal space: dividing the linear distance between the right clavicle and the ipsilateral costal arch into equal quadrants

Photo 12.1. The patient is placed in supine position and an inflatable bag is placed under the right scapula to tilt the rib cage to the left side. Sternotomy line is marked in case of conversion to conventional method.

and then making the incision in the middle of the second quadrant usually produces the best surgical view. Ideally, the right superior pulmonary vein should be in the exact center of the surgical field. If the variability in the patient's anatomical structure causes a bad view, we can easily pass to a lower or upper intercostal area from the same skin incision. Depending on the location of the ascending aorta or aortic valve, the second or third rib is separated from the costochondral junction with coarse scissors. When the surgery is completed, it is fixed with 2/0 Vicryl sutures.

A soft tissue retractor and an articulating retractor are used to help widen the intercostal space. The pericardium is opened as far away as possible, paying attention to the phrenic nerve, as in median sternotomy. Ideally, the pericardial incision is advanced downward toward the diaphragm to expose as much of the right atrium as possible. It is important to pay attention to proper hemostasis

Figure 12.1. Elevation of the right side facilitates the exposure.

of the prepericardial fat. With a strong, thick suture (2/0 silk), the pericardium is suspended in basically six regions: the first is placed at the level of the right superior pulmonary vein, the second is placed as cranially as possible (next to the pericardial reflection in the aorta), and the last is placed at the most caudal part; same sutures are also put on the left side pericardium, these sutures are passed through the chest wall and fixed (Photo 12.2, Figure 12.2). With the help of these pericardial suspension sutures, the heart comes closer to the surgeon (Photo 12.3).

TIPS & PITFALLS

- Structures to be considered while passing the intercostal space
  - Subcostal artery and vein
  - Right internal thoracic artery; if it will remain within the operating field, it should be divided appropriately to prevent bleeding.
- While opening the pericardium, attention should be paid to the right phrenic nerve. It should be kept in mind that the phrenic nerve courses more medially in the superior parts.

In this technique central or peripheral arterial and venous cannulation can be used. For central arterial cannulation, the aortic cannula is placed in the proximal part of the aortic arch after passing two purse-string sutures. It is of utmost importance to have the best visibility and control of the target point: a useful trick is to push the aorta down and toward you with a gauze pad and forceps. For venous cannulation, since it may be difficult to reach the inferior vena cava with a standard two-stage cannula, using a special L-shaped venous cannula would make it much easier. It is critical to put a purse-string suture to the area where the venous cannula will enter the atrium and to secure it with an additional binding around the cannula after it is placed in the atrium, to prevent accidental removal

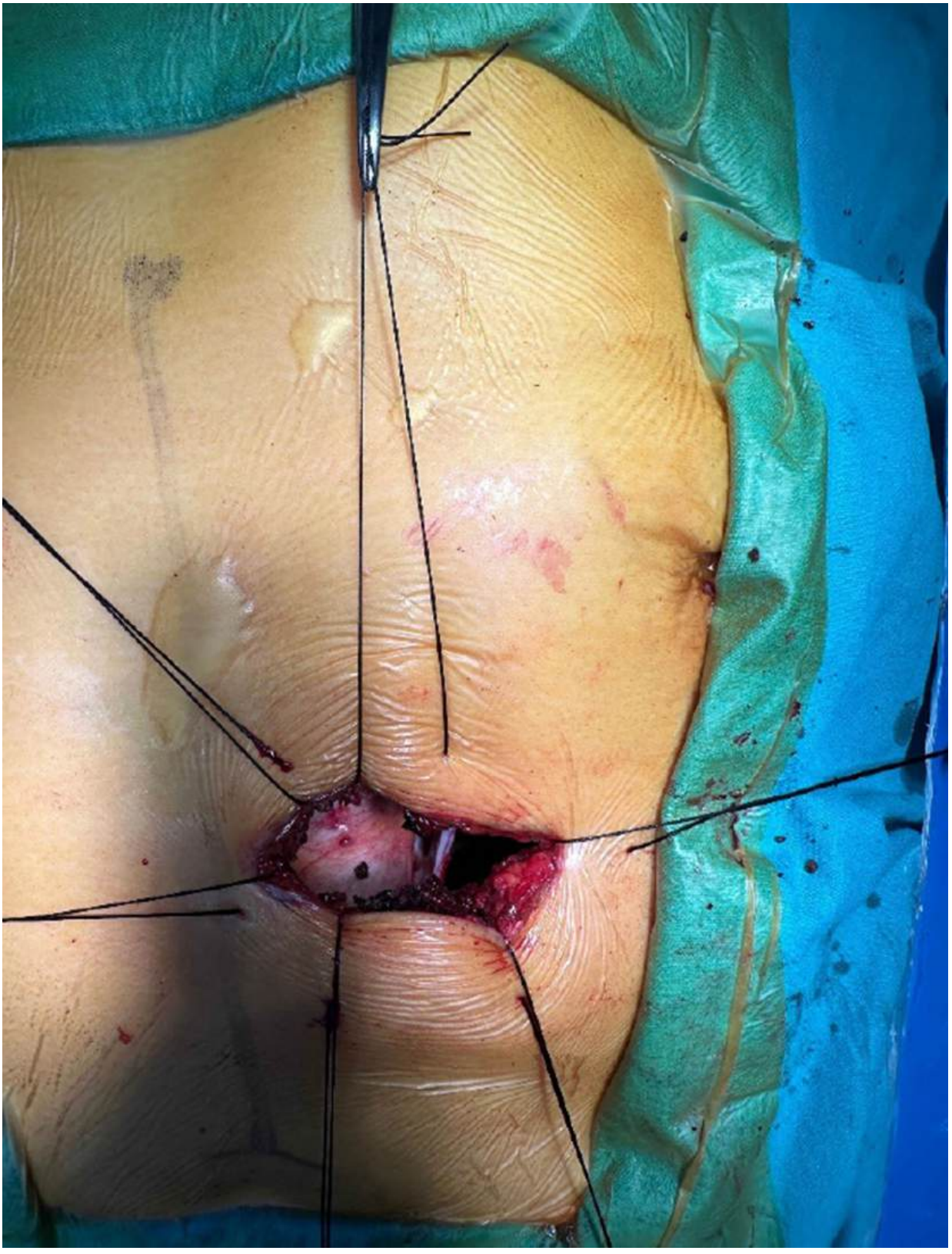

Photo 12.2. Pericardial stay sutures are passed following thoracotomy.

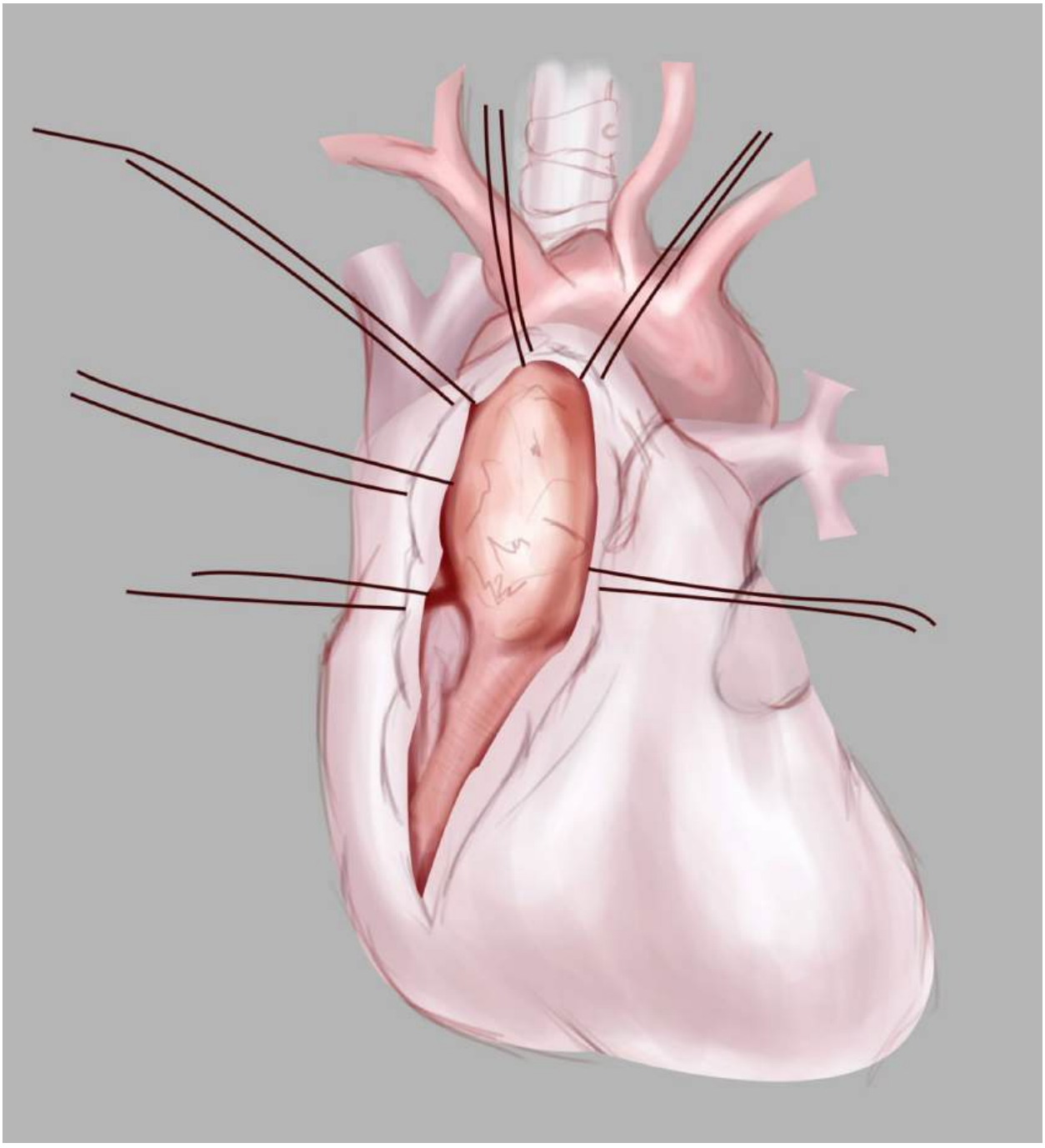

Figure 12.2. Stay sutures are passed from six regions: the first is placed at the level of the right superior pulmonary vein, the second is placed as cranially as possible (next to the pericardial reflection in the aorta), and the last is placed at the most caudal part; same sutures are also put on the left side pericardium, these sutures are passed through the chest wall and fixed.

of it. After the venous cannula is fixed, it is passed through the thorax wall and the auricle of the right atrium is removed from the aortic root, thereby providing better access to the aortic root. The left ventricle is ventilated as in routine procedures, from a small cannula inserted through the right

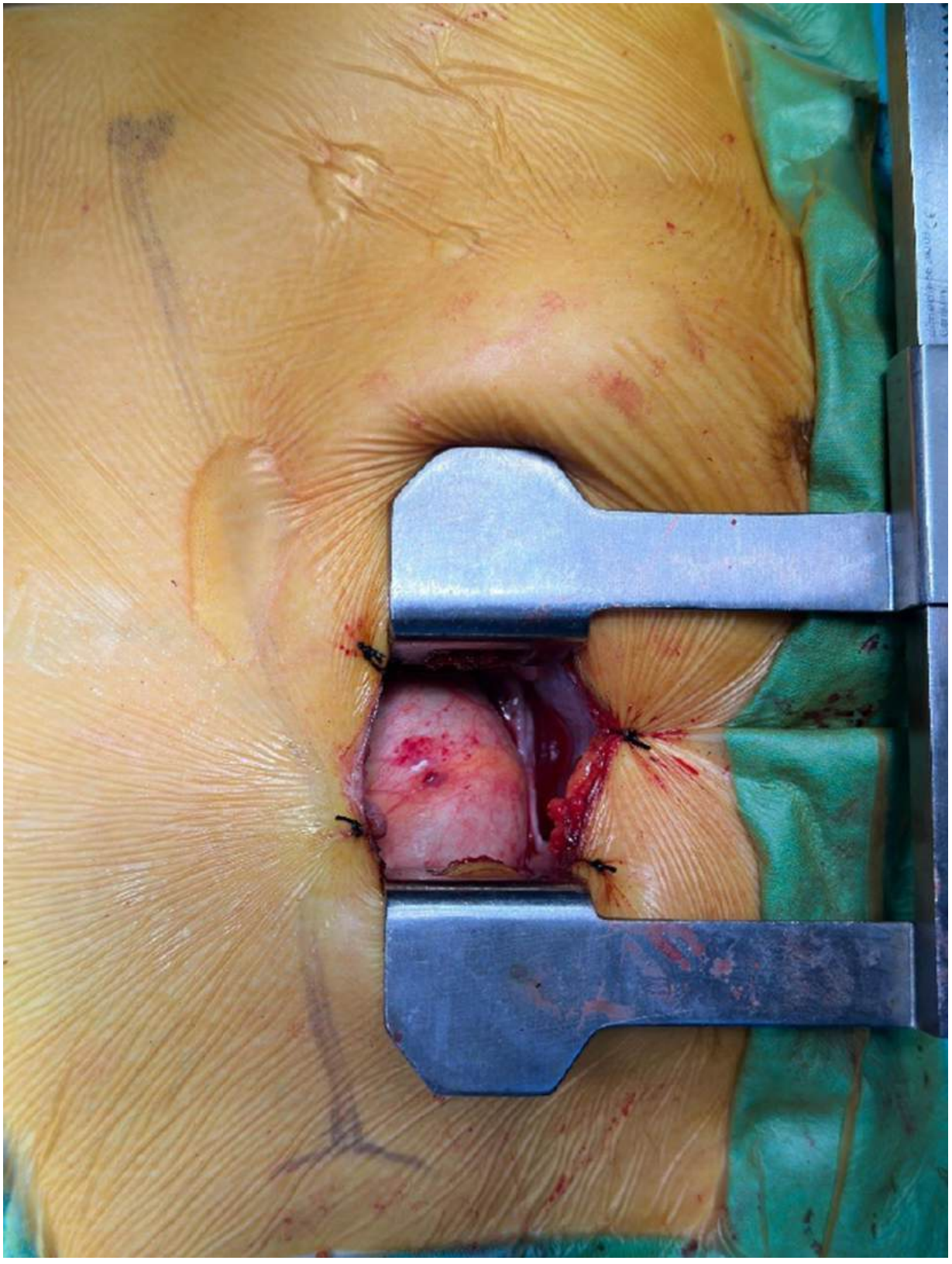

Photo 12.3. After pericardial stay sutures are tied, aorta becomes closer to the surgeon.

superior pulmonary vein. If central cannulation is not possible due to anatomical abnormalities or extensive calcification, peripheral percutaneous and/or open, arterial and/or venous cannulation is performed with appropriately sized cannulas.

In our center, if there is no contraindication, we start CPB with using right jugular venous, right femoral artery and venous cannulation accompanied by transesophageal echocardiography (TEE). It makes the operation easier, since there are fewer cannulas in our surgical field.

Continuous carbon dioxide insufflation at a flow rate of 3 L/min is used during the operation. The aorta is cross-clamped with a Chitwood DeBakey clamp at the exit of the innominate artery, without separating the aorta from the pulmonary artery.

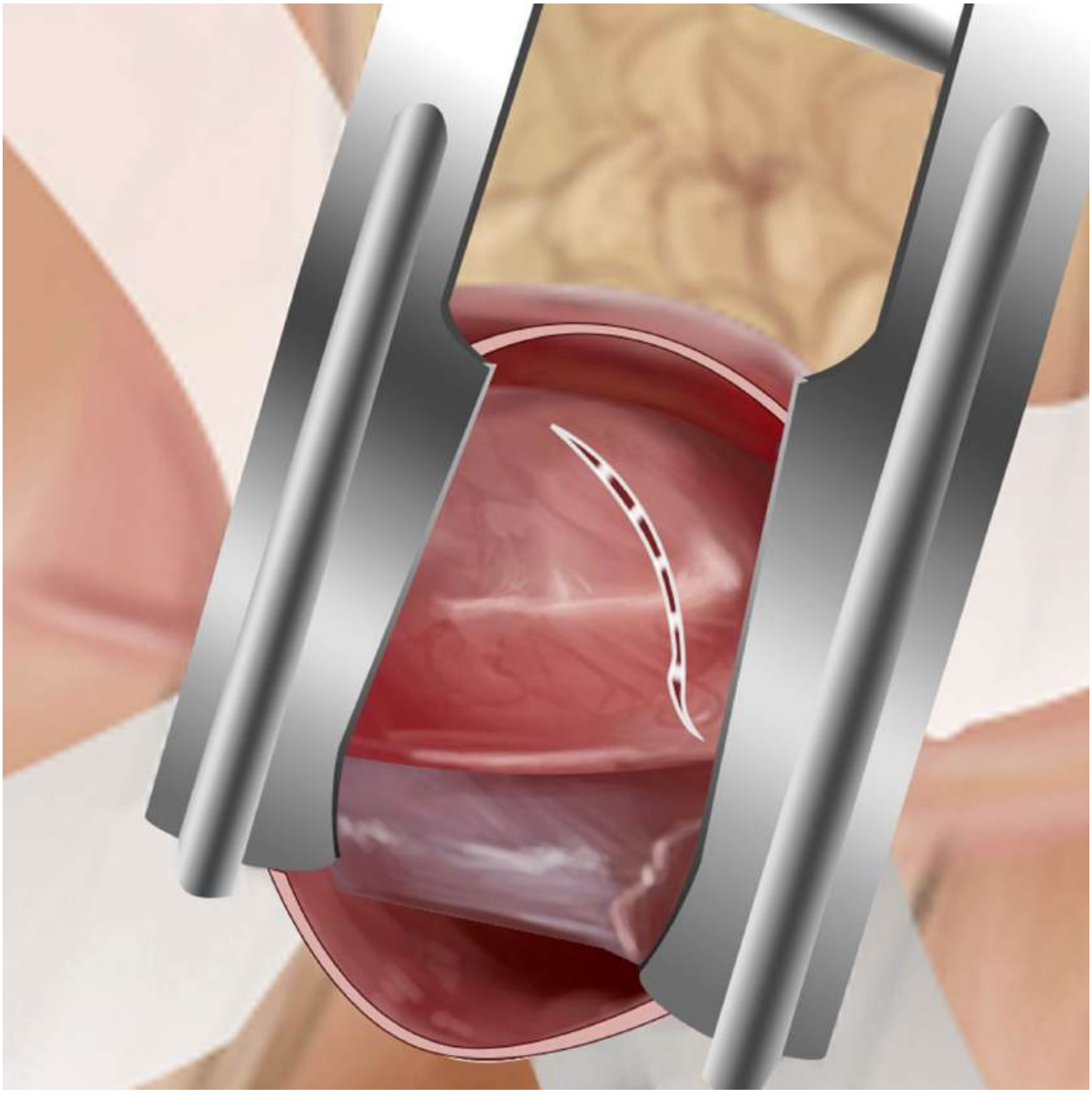

Figure 12.3. Aortotomy line is clearly seen following the exposure steps.

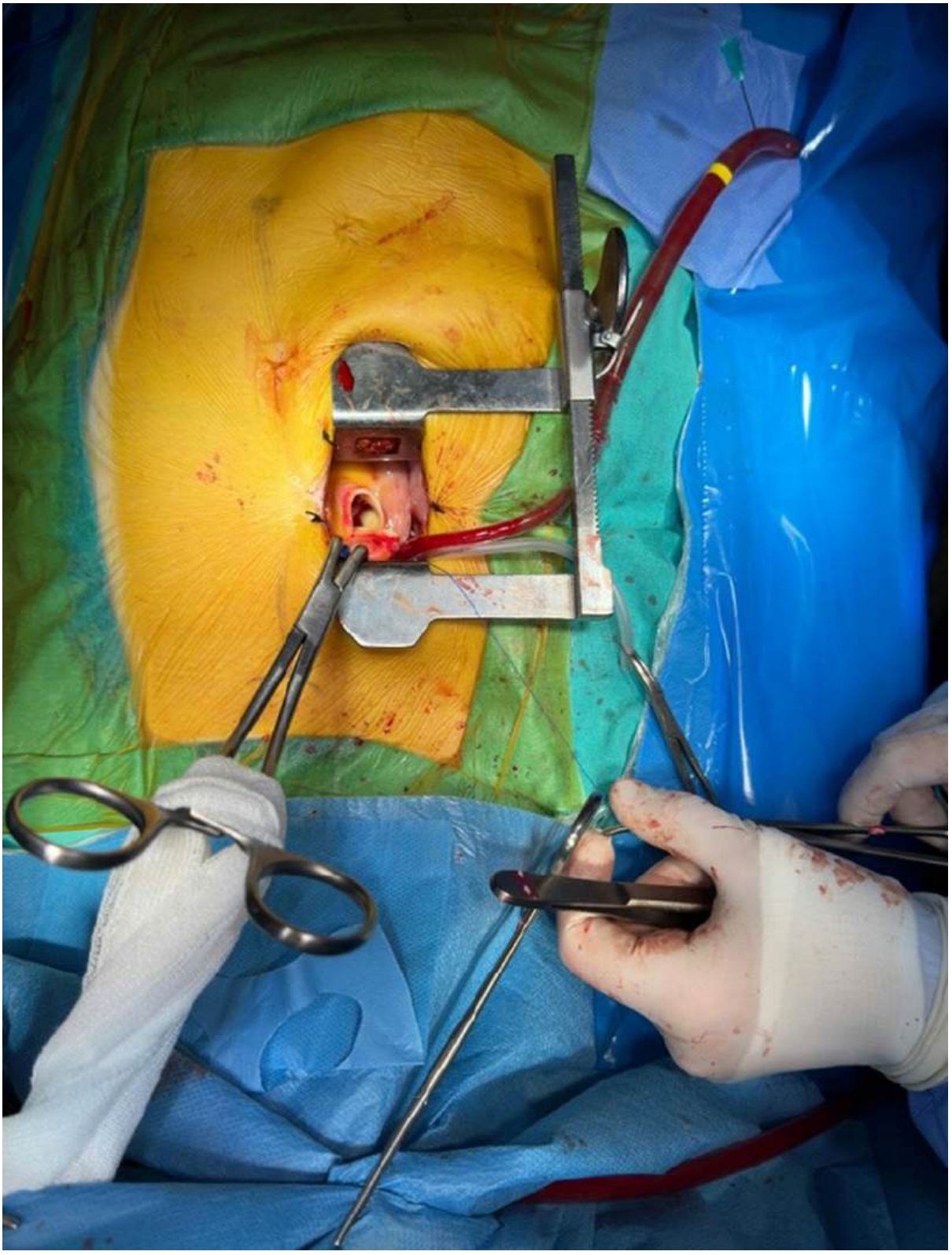

Photo 12.4. Aortotomy is performed following the cross-clamping of the aorta. Please note the vent cannula inserted into the right upper pulmonary vein, and peripheral arterial and venous cannulation is chosen to establish cardiopulmonary bypass.

To obtain a less crowded operating field, the aortic clamp is inserted through a separate skin incision of less than 1 cm, just below the lateral aspect of the clavicle, and placed in the transverse sinus: a suction tip can be used for blunt dissection while placing the cross-clamp. In our center, we use a Chitwood DeBakey clamp for short ascending aortas and a central cross-clamp for longer ascending aortas. Cold blood cardioplegia, Custodiol or Del-Nido (we use it routinely in our center) cardioplegia is applied in an antegrade style. Hypothermic (28°C-30°C) CPB is performed in all patients. A transverse incision is made in the ascending aorta and the aortic leaflets are excised *en bloc* (Figure 12.3, Photo 12.4). Sutureless or stitched prosthetic valves can be used. The preferred technique for sutured prostheses is to use three 2-0 Prolene sutures (120 cm) in three or four large steps for

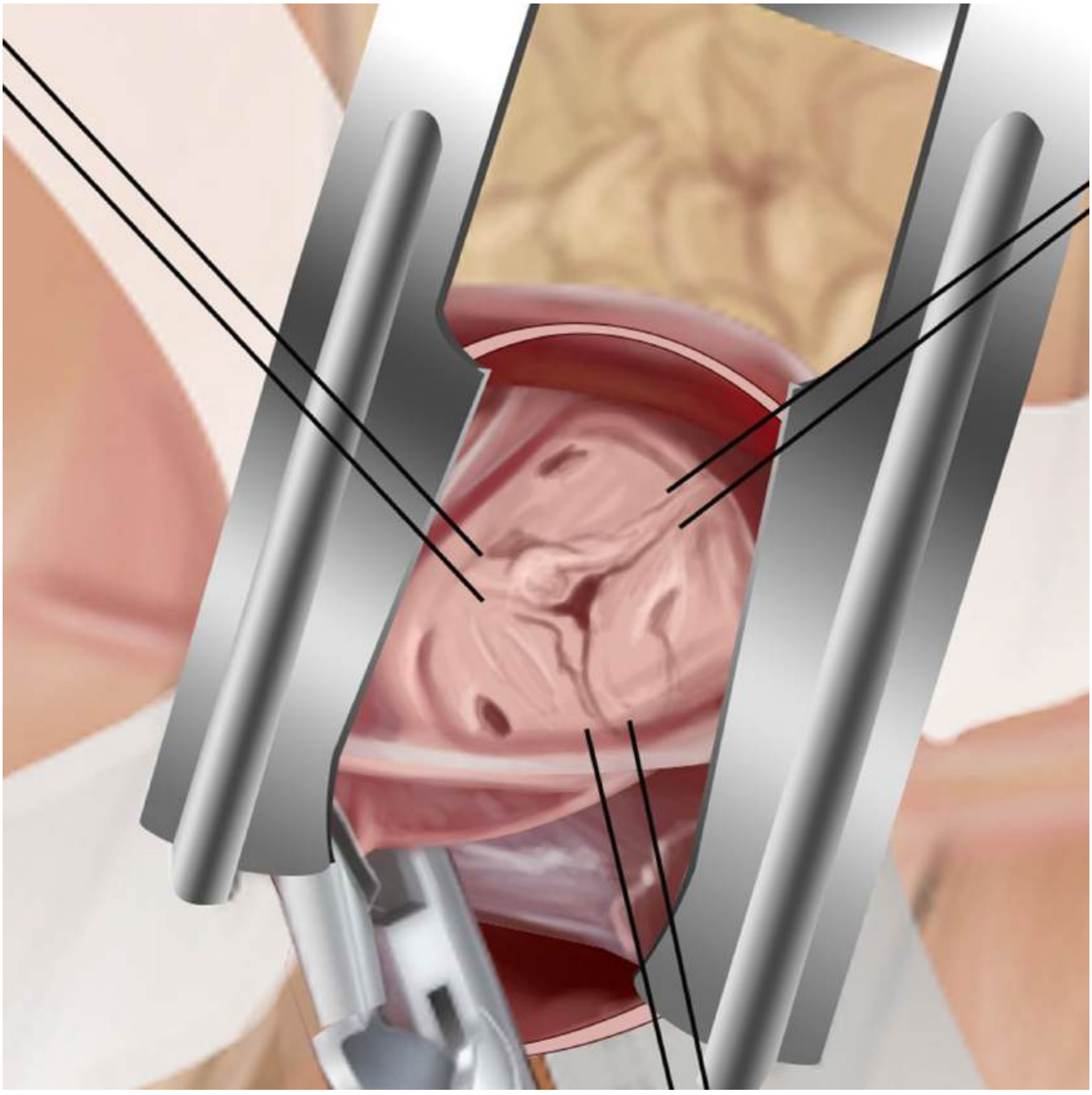

Figure 12.4. Three sutures passed from each commissure for better exposure.

each sinus, as in standard aortic valve replacement (Figure 12.4). Knots are tied with knot pusher, Cor-Knot™ (LSI Solutions, Victor, NY, USA), or conventional fingering methods (Photo 12.5).

In sutureless valves, only guiding sutures are used in accordance with the manufacturer's instructions. In general, passing three sutures corresponding to the aortic commissures is sufficient. While completing the sutureless valve implantation, the prosthetic valve must be dilated with the help of a balloon at a sufficient pressure and for an appropriate period of time. Removing the air is done by slowly filling the heart. The ascending aortic incision is closed with a single or double 4-0 prolene suture, depending on the quality of the aortic wall. The aortic clamp is removed and the patient is weaned from CPB. Temporary pacemaker wires are placed in the right ventricle. The cannulas are taken out and protamine is administered. Hemostasis is critical while working in a narrow space; therefore, it is important to use polytetrafluoroethylene (PTFE) plegets in cannulation sutures, which will contribute to hemostasis.

TIPS & PITFALLS

- Central cannulation
  - Smaller incisions and less surgical trauma
  - May interfere with the surgical site
  - Difficult to intervene in case of bleeding
- Peripheral cannulation
  - Extra incision; possible wound site complications in the femoral region
  - An open surgical view without cannulas
  - Possibility of developing vascular complications
- While choosing a valve, it should be kept in mind that sutureless prosthetic valves can reduce cross-clamp time.
  - When damage may occur to the conduction pathways adjacent to the aortic valve due to the nature of the operation, ventricular temporary pacing wires must be placed without removing the cross-clamp.
  - In centers where Mi-AVR RAT program has just started, getting support from surgeons who are experienced in this field will ensure that the learning curve progresses in a healthy way and reduces the possible complications that may be encountered in the initial phase.
  - Patient selection is of paramount importance at the initial stage. At this stage, it is essential to comply with the anatomical criteria regarding the position of the ascending aorta that we mentioned before.
  - At the beginning of the learning curve, patients with high fragility index and severe aortic should be avoided.

Over the last two decades, trends in surgical valve procedures have been rapidly shifting toward minimally invasive strategies. With the introduction of TAVI, surgical procedures face challenges due to the faster mobilization of patients, shorter length of stay in the ICU and hospital, and less surgical trauma offered by TAVI.

Although Mi-AVR is often associated with longer cross-clamp and operation times, it has proven to be a feasible and safe procedure with lower postoperative mortality even in high-risk and elderly patients. Indeed, RAT not only preserves sternal stability by providing rapid mobilization, but also prevents postoperative bleeding, offers lower blood transfusion rates and shortens the length of stay in the ICU. It is known that cross-clamp time is an independent determinant of morbidity and mortality in cardiac surgery. By combining the RAT approach with sutureless valves, operation and cross-clamp times can be greatly reduced.

Additionally, the RAT approach increases patients' satisfaction by providing excellent cosmetic results with less pain and faster return to work.

Although surgeons must go through a learning curve to perform Mi-AVR via the RAT approach, it can be performed with an excellent hemodynamic profile and low postoperative complication rate.

Preoperative imaging and careful planning are the keys to success in Mi-AVR. Superior cosmetic outcome results in higher patient and referring physician satisfaction.

TROUBLESHOOTING

- Surgical vision is poor.
  - Second intercostal space can be tried instead of third.

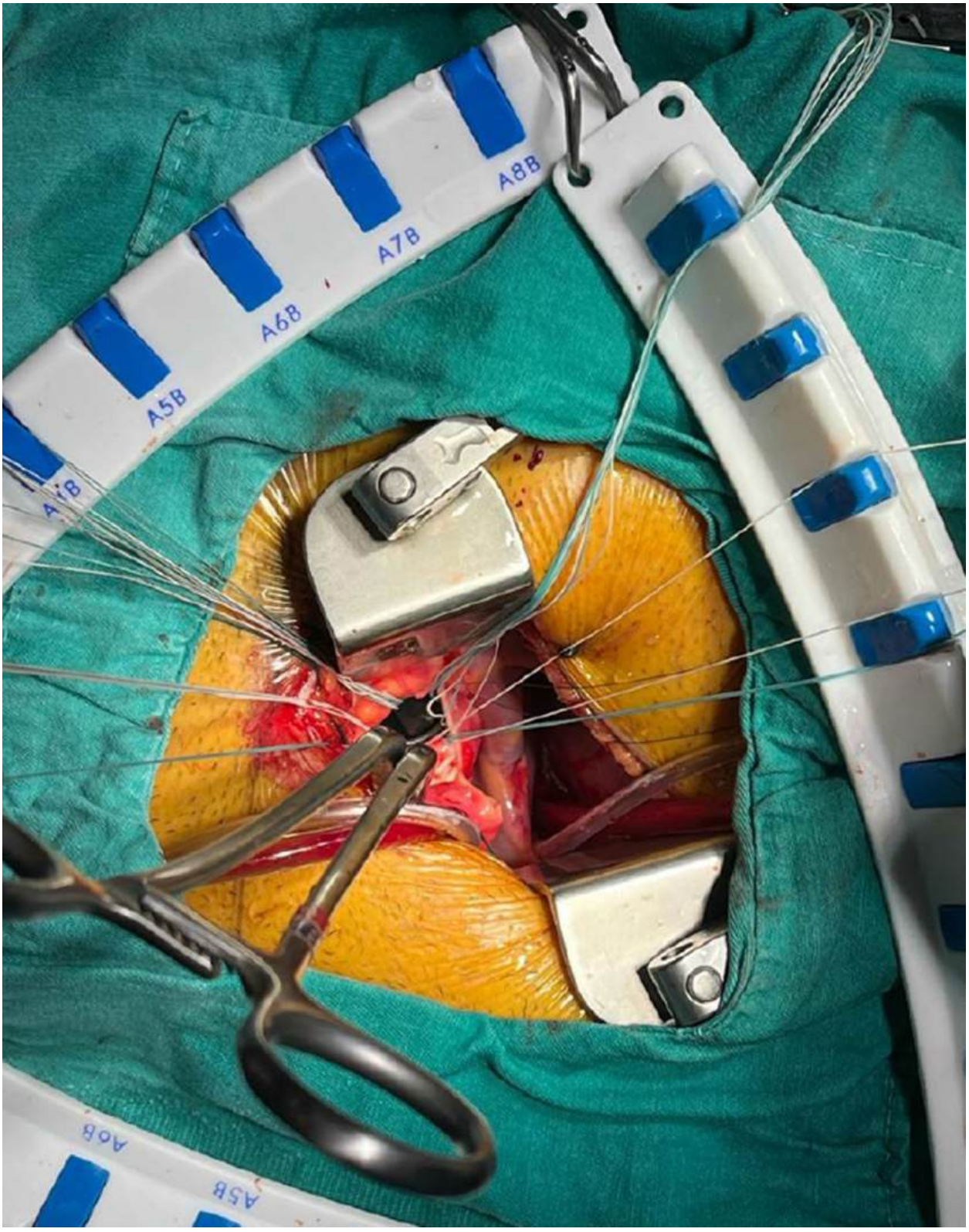

Photo 12.5. Sutureless valves may be easier to implant via RAT, however; mechanical valves are also able to be implanted using knot pushers, as well as surgeons may choose to use hands to tie knots in most conditions.

- The heart is brought closer to the surgeon by stretching the pericardial sutures.
- The ribs can be temporarily separated from the costochondral junction.

✦ In case of a possible complication, the option of emergent sternotomy should always be considered.

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