Exposure

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Abstract

Exposure of the target coronary artery is the first step in successful off-pump coronary artery bypass grafting (OPCAB). Deep pericardial suture ("Lima suture") and other modified techniques have contributed to the widespread use of OPCAB. In the basic deep pericardial stitch technique, the posterior pericardium is lifted up with three sutures and the heart is displaced. OPCAB has become more widely used since suction-assisted heart positioning devices were developed. Apical suction devices are only applied at the apex, and the heart is lifted and rotated to expose the target coronary artery. Our group developed a multi-suction heart positioner, Tentacles, which can facilitate this exposure. Patient positioning is also effective in any heart displacement technique. The operating table should be tilted in the Trendelenburg position and rotated sideways to the right for exposure of the left circumflex territory and the inferior territory. Heart displacement can cause hemodynamic instability in any heart positioning technique. Positioning for the left circumflex territory results in the greatest impairment to circulation compared to other territories. The main cause of hypotension is right ventricular kinking/obstruction, regional wall motion abnormality caused by compression and regional ischemia, and mitral regurgitation caused by mitral annular distortion. Fluid redistribution, patient positioning, catecholamine infusion, coronary perfusion during distal anastomosis, and pacing are effective in improving circulation.

Keywords

Off-pump coronary artery bypass grafting • Deep pericardial stitch • Heart positioner

9.1 Exposure

The key to successful off-pump coronary artery bypass grafting (OPCAB) is exposure of the target coronary artery under stable and acceptable circulation, effective stabilization of the local area, and identification of an optical anastomotic site with or without coronary perfusion. Exposure and visualization of the target coronary artery is the first and most essential step. If the target coronary artery cannot be visualized, the off-pump coronary bypass procedure must be converted to an on-pump procedure or bypass grafting to the target vessel must be omitted. When the heart is in an anatomical position, the left circumflex artery (LCx) (such as the obtuse marginal artery {OM} and the posterior lateral artery {PL}) is positioned on the back side of the heart, the posterior descending artery (PD) and the atrioventricular branch (AV) are adjoined to the diaphragm, and the left anterior descending artery (LAD) and diagonal branch (D) are adjoined to the left lung. Only the main trunk of the right coronary artery (RCA) can be approached in the anatomical position. To visualize all other coronary arteries, the heart must be displaced using

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various techniques and devices. For successful OPCAB, cardiac surgeons and anesthesiologists must cooperate to obtain an optical operative field and maintain stable patient circulation during anastomosis.

9.2 Deep Pericardial Stitch and Other Non-Device-Based Techniques

There are two types of heart displacement techniques. Before heart positioning devices were developed, deep pericardial stitch, the so-called Lima stitch, was the basic technique used to displace the beating heart. In this technique, three deep sutures are placed at the posterior pericardium: one at the junction between the pericardium and the left superior pulmonary vein, one at the junction of the pericardium and the left inferior pulmonary vein, and one in the middle portion of the pericardium between the left inferior pulmonary vein and the inferior vena cava [1]. The posterior pericardium is lifted with these three sutures and the heart is displaced. Various target coronary territories can be exposed using different combinations of elevations of the three deep pericardial stitches and lateral displacement. At this time, the position of the patient is important for proper access to the target artery. The table is set in the Trendelenburg position for the inferior territories (PD and AV branch), and the table is rotated sideways to the right for the posterior territories (OM and PL). The body is placed in the horizontal position for the anterior territories. The target anastomotic site is then stabilized with a suction-type stabilizer.

During placement of the deep pericardial sutures, great care should be taken to avoid a deep puncture. The stitch can cause serious bleeding from the large vessels of the posterior mediastinum such as the pulmonary veins [2] and descending aorta [3]. The stitch can also injure the esophagus. To avoid these serious complications, the suture should be passed through the posterior pericardium twice. At first, the suture should be passed superficially. The assistant should pull the thread in such a way as to give the pericardium a convex shape, moving it away from the structures of the posterior mediastinum. Then, the surgeon should pass the thread more deeply through the pericardium [1].

The "single-suture" technique is a modification of the "Lima suture." This suture is similar to the third suture of aforementioned technique [4, 5]. The heart is elevated with one hand, and a single stitch (0 silk or no. 1 monofilament suture) is placed in the oblique sinus (pericardium between the left inferior pulmonary vein and the inferior vena cava), and the suture is passed through a folded 15 in. vaginal tape at the end, which doubles over on itself. Then, the suture is snared, pushing the vaginal pack flush with the pericardium. The suture is clamped to the snare and is pulled caudally in the midline and clamped to the drapes. Tension of the vaginal pack at 90° to the retractor on the left side allows elevation of the heart outside the chest. The vaginal pack is clamped to the drapes and is used for visualization of the LAD, diagonal branch, and intermediate artery. When the vaginal pack is opened into two arms and tension is placed on one of the arms toward the right and the tension is placed on the other toward the left, the apex of the heart is pointed toward the ceiling and the PD, PL, and OM can be exposed. Opening the right pleuropericardial space allows the heart to herniate into the right chest, and exposure of the LCx can be facilitated. This "single-suture" technique is arranged in various ways by some surgeons to obtain a better optical anastomotic site and maintain the patients' hemodynamic condition during anastomosis [6]. At the time of heart displacement for the expose of the posterior and inferior territories, the right ventricle (RV) is likely to be kinked and compressed, and the diastolic filling of the RV might be disturbed, followed by hemodynamic instability [7].

9.3 Apical Suction Device and Multi-suction Device

Deep pericardial stitch techniques used to expose various coronary territories have contributed greatly to the increased use of OPCAB. However, after apical suction devices such as Starfish® (Medtronic, Inc, Minneapolis, MN) and X-pose® (MAQUE, Cupertino, CA) were developed, many surgeons began to use these devices because of their easy manipulation and reliable function (Fig. 9.1). To expose the target coronary artery, the vacuum-assisted apical suction device is applied at the apex of the heart to elevate and rotate the left ventricle into the midline. The level of vacuum pressure typically needed to maintain capture of the heart varies between

Fig. 9.1 A representative of an apical suction heart positioner: X-pose® (MAQUE) and other devices for off-pump coronary artery bypass grafting (MAQUE)

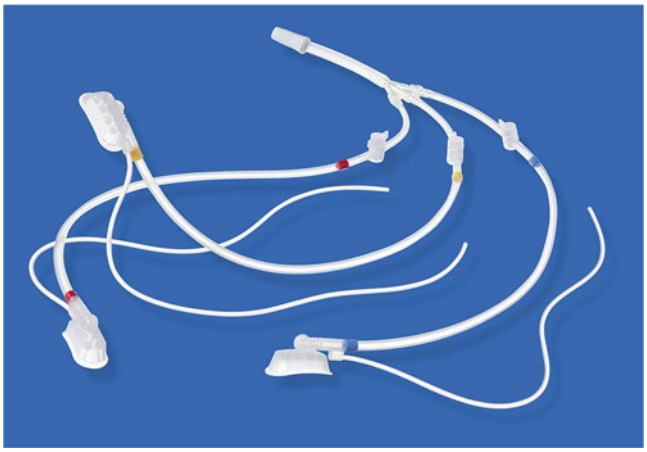

Fig. 9.2 A multi-suction heart positioner: TENTACLES™ (Sumitomo Bakelite Co., Ltd, Tokyo, Japan)

200 and 250 mmHg. The apex of the heart is slightly moved to the midline for exposure of the LAD. The apex is lifted to the ceiling and rotated to the cranial side for exposure of the inferior territory and lifted and rotated to the right lower side for exposure of lateral and posterior territories. To facilitate the exposure, the operating table is tilted in the Trendelenburg position and rotated to the right side in the same manner as mentioned above. Opening the right pleura also helps to rotate the heart. Inadvertent traction using any suction-type heart positioner can possibly cause tear at the epicardium and fat tissue around the apex, causing bleeding. Serious bleeding is rare; however, it is necessary to finish bypass procedure as quickly as possible and neutralize heparin and compress the bleeding site to stop bleeding.

We developed a multi-suction cardiac positioner, TENTACLES™ (Sumitomo Bakelite Co., Ltd, Tokyo, Japan) (Fig. 9.2) [8]. This device has three independent small suction cups and arms with elastic silicone strings. Due to the high tissue affinity of the suction cup, the suction cups can be applied on any surface of the heart and pulled in any desired three different directions using traction string, which is fixed to the surgical drape using clamp. To visualize the LAD, we typically apply one suction cup on the anterior wall of the RV and pull the RV rightward. To secure the heart position, we usually apply another additional suction cup at the LV anterior wall and fix it loosely to the left side (Fig. 9.3a). But anastomosis to the LAD can be performed even with only one or two suction cups applied on the RV, owing to the powerful suctioning capacity of this device. In case of unstable heart such as acute anterior wall myocardial infarction or low ejection fraction, this LV non-touch maneuver is especially useful to avoid suction-induced injury to the weakened infarcted myocardium, hypotension, or life-threatening arrhythmia induced by touching the LV wall. To visualize the inferior wall, we usually apply one suction cup on the RV anterior wall and pull it cranially and another cup on the inferior wall near the apex and slightly lift the apex under the sternum. In addition, we apply third suction cup on the RV inferior wall near the acute margin and pull it in the right-cranial direction to expand exposure of the inferior wall (Fig. 9.3b). The PD can be easily exposed under stable hemodynamic conditions. To visualize the lateral wall, we apply the first suction cup on the apex and lift the heart to confirm the target coronary artery. The second suction cup is applied on the LV lateral wall to rotate the heart rightward, and the traction string is fixed at the right side drape. The third suction cup is applied deeply near the crux of the heart and pulled in the left-caudal direction, and then fixed at the left side drape. Heart is rotated toward the right chest cavity (Fig. 9.3c). Finally, the first suction cup on the apex is detached. The apex is displaced under the right-sided sternum. Additional application of one suction cup on RV outflow tract may sometimes be helpful to prevent RV outflow kinking.

According to the annual report of Japanese Association for Coronary Artery Surgery 2012, suction heart positioner was utilized in 87 % of overall Japanese coronary surgery units.

9.4 Hemodynamic Change Caused by Heart Displacement

Hemodynamic changes are observed in any heart displacement technique. Although both deep pericardial traction and vacuum-assisted suction are safe and effective maneuvers to expose the coronary artery in OPCAB, vacuum-assisted suction devices appear to produce lesser hemodynamic impairment than the deep pericardial traction technique [9, 10]. Transesophageal echocardiography is very useful for quickly detecting signs of hemodynamic instability [11]. Hemodynamic changes are considered to result from RV kinking and obstruction, regional wall motion abnormalities caused by transient ischemia, or compression of the heart by stabilizers. Mitral annulus distortion by heart displacement can cause mitral regurgitation [12].

Cardiac surgeons must collaborate with anesthesiologists to obtain and maintain acceptable hemodynamic stability during distal anastomosis for successful OPCAB surgery. Fluid redistribution, rotation of the patient's position, perfusion of the target coronary artery, catecholamine infusion (too much catecholamine is detrimental for OPCAB), pacing, etc. are effective in stabilizing the hemodynamic condition; however, transient reposition of the heart to the anatomical position have to be considered when hypotension persists [13]. In case stable hemodynamic condition cannot be obtained, utilization of intra-aortic balloon pumping or conversion to on-pump CABG should be decided without delay. Emergent resuscitation and conversion to on-pump beating CABG should be avoided because of the high morbidity and mortality [14].

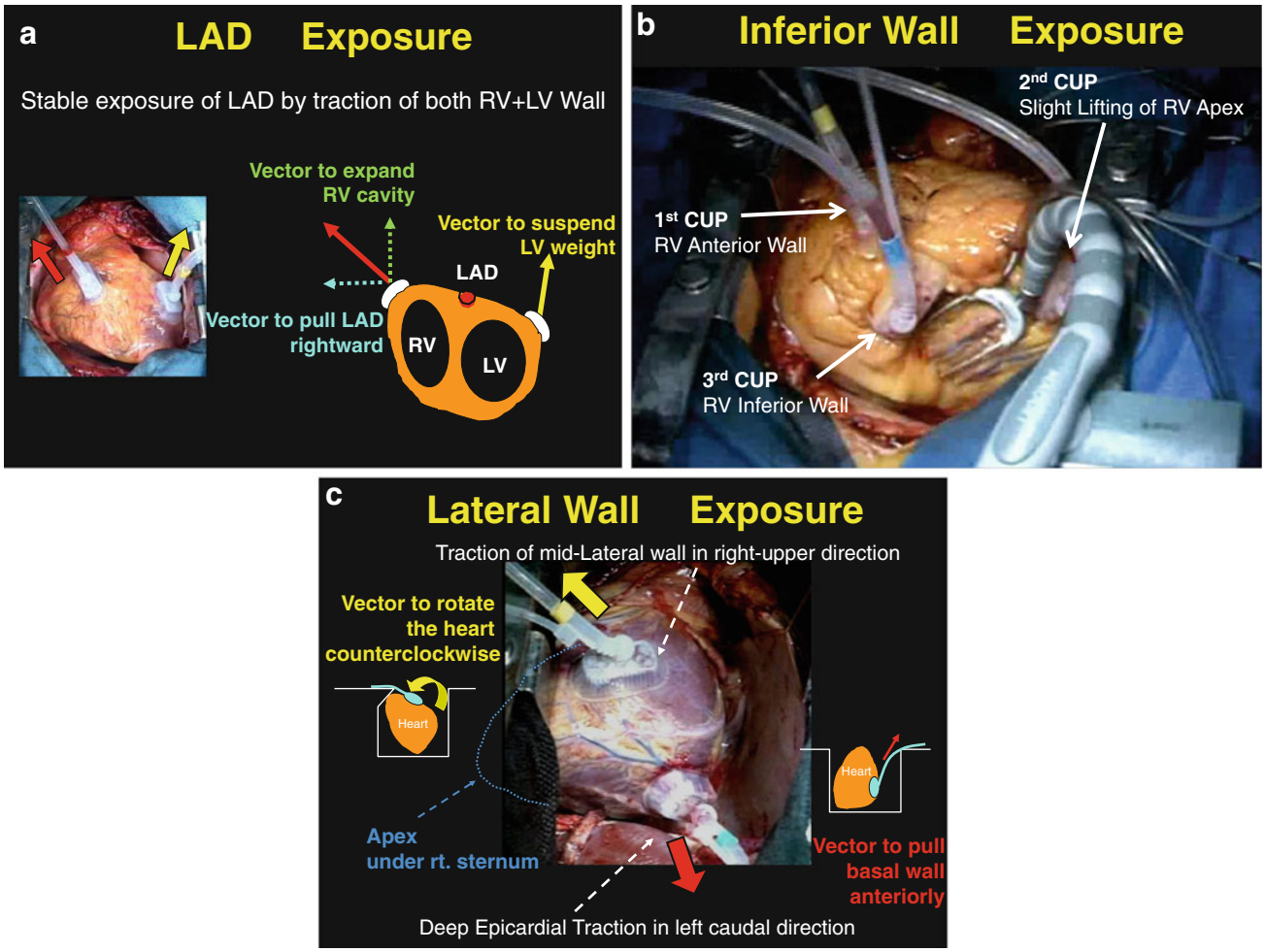

Fig. 9.3 Exposure of coronary arteries using TENTACLES™. (**a**) Exposure of left anterior descending artery. (**b**) Exposure of posterior descending artery. (**c**) Exposure of posterior lateral artery

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