Case Report

The role of image intensifiers in minimally invasive cardiac surgery: A case report

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ABSTRACT

Transesophageal echocardiography (TEE) is a critical tool in total coronary revascularization via anterior thoracotomy (TCRAT). It provides real-time imaging that enhances intraoperative decision-making. However, it can be a problem in patients with prior esophageal surgery. This case report explores the successful use of image intensifiers in a 64-year-old male patient who underwent TCRAT with prior esophageal surgery. Anatomical restrictions caused by the patient's subtotal esophagectomy made TEE infeasible. A hybrid operating room facilitated guidewire and peripheral cannula placement using image intensifiers, providing critical real-time imaging and guidance. This case's success illustrates the flexibility needed in sophisticated surgical settings as well as the incorporation of technology in cardiac surgery.

Key words: Esophageal surgery, Image intensifier, Minimally invasive cardiac surgery, Transesophageal echocardiography

Transesophageal echocardiography (TEE) helps with operations such as total coronary revascularization through anterior thoracotomy (TCRAT). It provides real-time imaging that enhances intraoperative decision-making and patient outcomes. The placement of guidewires in the arterial and venous system requires guidance for peripheral cannulation using the TEE [1]. Furthermore, it enables the continuous monitoring of cardiac function, wall motion abnormalities, and cardiac output, all of which ensure optimal surgical intervention [2]. However, performing such operations will be a concern particularly when TEE is not available or feasible.

Here, we discuss a patient with prior esophageal surgery, the problems we encountered in the absence of TEE, and how we surmounted the challenge of performing the TCRAT operation. This case emphasizes the need to adapt different surgical techniques to specific patient needs, using emerging technology to overcome intraoperative problems. The rationale of reporting this case is that by documenting the successful use of image intensifiers as an alternative to TEE, this case contributes to the expansion of imaging options in minimally invasive cardiac surgery (MICS). As MICS advances, image intensifiers offer a versatile alternative for intraoperative imaging in complex cases.

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CASE REPORT

A 64-year-old male initially presented with chest pain, shortness of breath, and diaphoresis for 1 day. His past medical history includes hypertension, dyslipidemia, diabetes mellitus, and esophageal cancer. Due to esophageal cancer, he underwent subtotal esophagectomy 3 years before the TCRAT surgery.

General examination showed a medium-built male, with no obvious abnormality except for a prior thoracotomy scar on the right which was well healed. The cardiovascular examination was normal. He was diagnosed with unstable angina based on the electrocardiogram and cardiac markers.

Chest X-ray showed no cardiomegaly and absence of lung field changes. Pre-operative ejection fraction was 57%. His coronary angiogram showed severe occlusion in the proximal left anterior descending, proximal circumflex, and mid-right coronary artery.

Therefore, he underwent TCRAT. Intraoperative transesophageal echocardiography (TEE) was abandoned due to resistance at 28 cm with both adult and pediatric probes, resulting in limited intraoperative imaging of the heart. A decision was made tWo transfer the patient to the hybrid operating room for insertion of guide wire and peripheral cannulation using image intensifiers as demonstrated in Figs. 1 and 2. He then underwent coronary artery bypass graft (CABG) surgery with saphenous vein graft to the posterior descending artery, obtuse marginal, and

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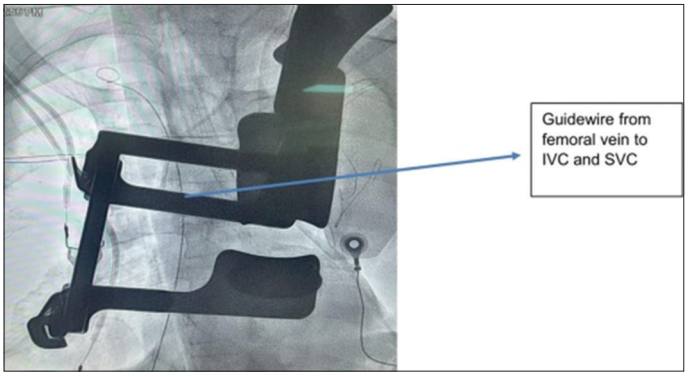

Figure 1: The guide wire placement in the inferior vena cava and superior vena cava before the femoral venous cannulation

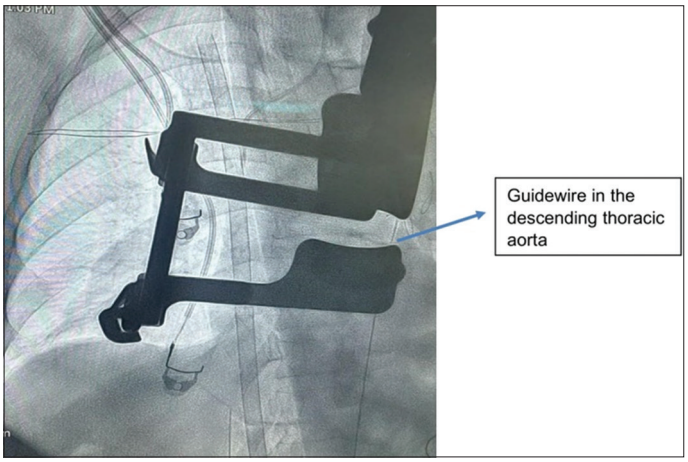

Figure 2: Guide wire placement during femoral artery cannulation

diagonal with left internal mammary artery to the left anterior descending artery through the TCRAT method. Postoperatively, the patient was extubated on day 1 and discharged on day 5. No wound infection or lower limb pseudoaneurysm was noted. He is progressing well during his 2-month follow-up.

DISCUSSION

This case of a 64-year-old male undergoing TCRAT illustrates the complexities of managing patients with prior surgical interventions. This patient's history of subtotal esophagectomy 3 years ago for esophageal cancer presented unusual anatomical problems, particularly from an intraoperative imaging point of view. TEE, was abandoned due to probe resistance at 28 cm in this patient. Post-operative scarring, adhesions, and esophageal lumen constriction likely would have caused this resistance. Therefore, patients with prior esophageal procedures require flexible surgical planning and alternate imaging modalities [3].

To overcome imaging issues, we moved the patient to a hybrid operating room for fluoroscopic guide wire insertion and peripheral cannulation. Image intensifiers and fluoroscopy provide accurate visualization and catheter insertion in difficult anatomical conditions such as in this patient. Instead of a median sternotomy, this patient had a less invasive anterior thoracotomy, which decreased the incidence of post-operative pain and hospital stay [4]. Moreover, this surgical approach may have reduced post-operative problems including infections, wound healing, and enhanced recovery compared to the standard CABG [5]. It also allows for a faster return to physical activity and a better quality of life [6].

Image intensifiers are essential for visibility and accuracy in MICS. Surgeons can maneuver around confined surgical spaces and enhance outcomes with real-time imaging. Fluoroscopy and C-arm computed tomography (CT) precisely position surgical instruments and catheters, thereby minimizing procedural mistakes. Fluoroscopy also offers good visualization of metallic objects as well as vascular structures, therefore making it a vital tool in procedures that require navigation of device such as in this case where navigation of peripheral cannula into the descending aorta and the superior vena cava and inferior vena cava [7]. Ohtsuka *et al*. in 2004 documented the usage of image intensifiers facilitating the hybrid operating room workflows whereby modern operating rooms integrate image intensifiers with robotic-assisted surgery and catheter-based interventions, expanding the role of MICS [8]. The most important element in our case is the proper vascular access. Mackay *et al*. reported that image intensifiers enhance the visibility of guidewires to ensure proper placement of the cannula which is crucial in the conduct of the surgery [1]. Despite its amazing ability for visualization of vascular structures, it too has its drawbacks. It lacks the ability to visualize soft tissue contrast, for example, visualizing cardiac chambers [9]. TEE on the other hand necessitates esophageal integrity; hence, image intensifiers are appropriate for patients with anatomical variations. They also offer the complete sight of extracardiac structures [10].

There are several studies that documented the role of fluoroscopy in MICS. Ohtsuka *et al*. reported that fluoroscopy enhanced safety in redo surgeries, especially for mini-thoracotomy coronary artery bypass. It aids in marking the target coronary artery such as the left anterior descending for mini-thoracotomy incisions [8]. It also now plays an important role in emerging cardiac therapies. It aids in the precise positioning and deployment of the aortic valve in transcatheter aortic valve implantation. Saeed *et al*. have now shown its importance in endovascular stenting in addressing aneurysms or occlusions [7]. Linden *et al*. discuss the critical role of imaging in MICS and highlight how advanced visualization techniques, including fluoroscopy, endoscopy, and CT-based planning, have transformed cardiac surgery [11]. Del Nido discussed how image-guided surgery is used in congenital cardiac surgery, focusing on non-invasive imaging techniques to assist in minimally invasive procedures [12].

Future research should create imaging modalities to replace or supplement TEE in individuals with changed thoracic architecture. In such cases, 3D fluoroscopy or intravascular ultrasonography may improve accuracy [13]. Research into less invasive imaging methods that avoid the esophagus might aid individuals with severe post-operative esophageal alterations. In complicated surgical circumstances, procedural flexibility and new technology can overcome conventional limitations and provide excellent results.

Comparisons of TEE with image intensifiers demonstrate their complementary advantages. TEE is superior for evaluating

functional heart structure, whereas image intensifiers are more effective for structural visualization and hybrid interventions. The advantage of TEE is that it protects the patient from radiation, whereas image intensifiers necessitate radiation shielding. Anatomically challenging situations such as this are favored for image intensifiers due to their versatility and adaptability. In a nutshell, the most important point to note here is that while TEE provides excellent cardiac imaging, it lacks the ability to visualize extracardiac vascular structures, which are crucial for procedures requiring peripheral vascular access, particularly in MICS cases where peripheral cannulation is crucial [5].

This instance emphasizes the importance of surgical planning and interdisciplinary teamwork. Surgical methods must be tailored to each patient's anatomical and physiological limitations. This shows the importance of integrating modern imaging techniques to manage complicated processes. Cardiothoracic surgeons, anesthesiologists, and imaging technicians worked procedural limits, and providing rigorous perioperative care to enhance recovery and prevent complications.

CONCLUSION

The successful use of image intensifiers in this case highlights their critical role as an alternative imaging modality in MICS, particularly in patients where TEE is contraindicated. TEE remains the gold standard for intraoperative cardiac assessment, but anatomical limitations, such as those posed by previous esophageal surgery, necessitate alternative strategies. Image intensifiers, through fluoroscopic guidance, facilitate real-time visualization of vascular structures and precise catheter placement. Their integration into hybrid operating rooms further expands their utility in MICS.

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