Angiographic confirmation of graft patency after coronary artery bypass graft surgery using interrupted nitinol clips

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The development of individual nitinol metal clips (U-CLIPs, Coalescent Surgical, Inc, Sunnyvale, Calif) that retain their memory when at body temperature has allowed surgeons to easily create an interrupted anastomosis between veins and arteries or between other hollow organs (1). The interrupted anastomosis necessarily precludes the "purse-string" effect that hand-sewn anastomoses can incur (2, 3). Some researchers have shown increased compliance with the U-CLIP interrupted anastomosis (4, 5). The clips are small, versatile, reliable, and easily applied in the open technique or by using robotics. The following case report demonstrates the efficacy of U-CLIPs in coronary artery bypass graft surgery.

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A 57-year-old man developed an anterior wall acute myocardial infarction complicated by ventricular fibrillation at an outlying hospital. Cardiac catheterization showed 4-vessel coronary artery disease, including an occluded left anterior descending artery, 90% diameter narrowing of the first diagonal branch, a 99% stenotic circumflex marginal branch, and an occluded right coronary artery. An intraaortic balloon pump was placed. The patient was transported emergently to Baylor University Medical Center (BUMC) for further care.

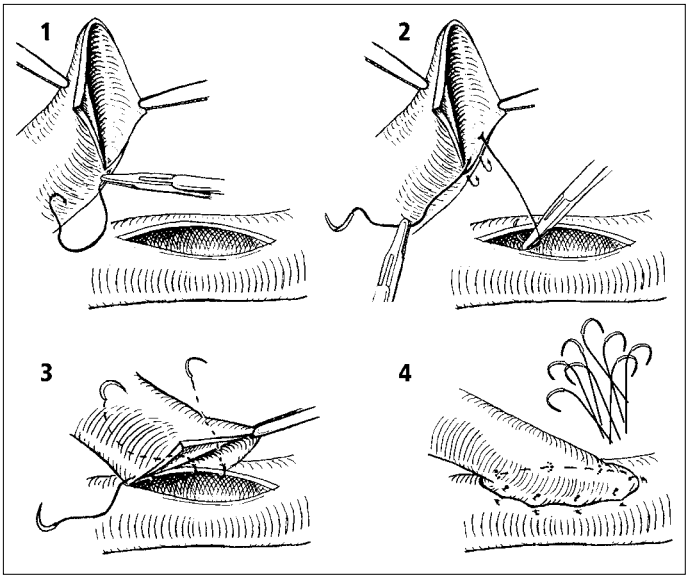

Figure 1. Deploying the nitinol U-CLIPs. Illustration by Susan Decker.

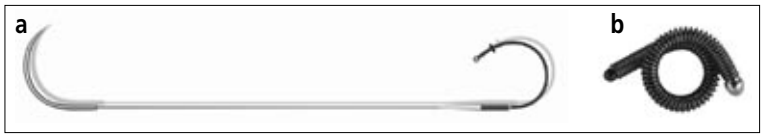

Figure 2. (a) Structure of the nitinol U-CLIP connected to the flexible member and **(b)** close-up of the U-CLIP in the omega configuration. Images courtesy of Coalescent Surgical, Inc.

At BUMC, urgent coronary artery bypass graft surgery was performed employing an internal mammary artery pedicle graft to the left anterior descending coronary artery; the saphenous vein graft was attached to the aorta and to the 3 coronary arteries distally. Each distal anastomosis was created in a way that allowed the surgeon to place 12 individual clips in a symmetrical fashion *(Figure 1)*. This "porcupine" technique afforded optimal visualization of all clips prior to their deployment to their final, omega configuration *(Figure 2)*.

The intraaortic balloon pump was removed on the third postoperative day, and the patient was transferred to the telemetry unit on the fourth day. The patient recovered normally until, after vigorous ambulation, he developed ventricular tachycardia on the fifth postoperative day. He was returned to the intensive care unit. An urgent repeat catheterization was performed *(Figures 3* and *4)* to confirm that all anastomoses were widely patent.

An electrophysiology study for inducibility of ventricular tachycardia/ventricular fibrillation was performed. An implantable cardiac defibrillator was placed. The patient was dismissed to home 1 day after the defibrillator implantation and was treated with amiodarone, aspirin, atorvastatin, enalapril, isosorbide mononitrate, and metoprolol.

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The interrupted anastomotic technique has been held by some as the gold standard for coronary anastomoses (6). Loop et al reported that the interrupted technique was used in patients who demonstrated the best long-term patency of mammary-to-coronary-artery anastomoses (7). Creation of the interrupted anastomosis with multiple sutures during routine and minimally invasive coronary artery bypass graft surgery can be cumbersome for the uninitiated. Tying reliable knots inside a small space without creating a purse-string effect requires skill, patience,

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Figure 3. Postoperative angiogram showing the left internal mammary artery and its connection to the left anterior descending coronary artery.

Figure 4. Postoperative angiogram showing a saphenous vein graft and its 3 distal coronary anastomoses.

and sophisticated equipment. Individually deployable clips were developed to circumvent these tribulations and to facilitate use of the interrupted technique in minimally invasive or robotic cardiac surgery.

To reduce the learning curve during robotic surgical techniques, we employed the clips in the open setting while using the cardiopulmonary bypass pump, as in this case. The follow-up coronary angiography (Figures 3 and 4) confirmed optimal distal anastomotic patency.

Factors that affect anastomotic patency include inflow, runoff, compliance, and the geometry of the connection. Inflow and runoff are immutable. Purse-string effects of malpositioned continuous suture are likely to reduce patency rates. Interrupted sutures or clips prevent such an effect. Anastomoses created with interrupted sutures or clips have been studied in the laboratory and shown with the ultrasound Doppler flow probe to have increased compliance and flow characteristics (4). Increased compliance presumably will reduce neointimal hyperplasia and increase patency.

The U-CLIPs are versatile and are used in peripheral vascular anastomoses, venous-to-arterial anastomoses, and esophageal and bowel anastomoses. Initially developed for use in especially small spaces, they are therefore easily used in robotic cardiac surgery as well as in the open technique. We estimate that use of these or similar devices will be important in further development of minimally invasive coronary and valve cardiac surgery.

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