A Retrospective Study to Evaluate Use of Negative Pressure Wound Therapy in Patients Undergoing Bilateral Internal Thoracic Artery Grafting

Giuseppe Santarpino, MD; Lazlo Gazdag, MD; Joachim Sirch, MD; Ferdinand Vogt, MD; Miroslaw Ledwon, MD; Theodor Fischlein, MD; and Steffen Pfeiffer, MD

Abstract

Bilateral internal thoracic artery (BITA) grafting may be associated with a higher risk of postoperative deep sternal wound infection than monolateral internal thoracic artery grafting due to a limited blood supply to the thoracic chest wall. Because preliminary studies suggest negative pressure wound therapy (NPWT) may reduce the risk of infection, a retrospective chart review of 129 patients who underwent BITA between February 2003 and October 2014 was conducted. Of those, 21 patients received NPWT for 5 days immediately following surgery and the incisions of 108 patients were covered with a conventional gauze dressing. Patient demographic and history variables as well as surgical procedure and outcome variables were abstracted. Outcome variables assessed included infection, need for transfusion, and length of hospital stay. The NPWT group was significantly younger (average age 55.9 ± 7.6 versus 60 ± 10.5 years, $P = 0.049$), had fewer urgent/emergent surgeries (4 [19%] versus 36 [33.3%], $P = 0.247$), and had significantly lower surgical risk scores (2.0 ± 2.3 versus 3.8 ± 2.8, $P = 0.010$). The rate of deep sternal wound infections was lower in the NPWT than in the control group, but the difference was not statistically significant (0% versus 5.6%, $P = 0.336$). Sternal instability was noted in 4 control patients, requiring wound re-exploration versus 0 in the NPWT group (3.7% versus 0%, $P = 0.487$). One (1) patient in the NPWT group had postoperative bleeding that required removal of the device. The rates of re-thoracotomy due to bleeding were 9.3% in the control compared to 4.8% in the NPWT group ($P = 0.435$), which translated into a greater need for blood transfusions (1.77 ± 3.4 units versus 0.3 3± 0.7 units, $P = 0.056$) and larger chest drainage volume (997.8 ± 710 mL versus 591.2 ± 346 mL, $P = 0.012$) in the control group. Hospital stay was longer in the control group, but the difference was not statistically significant (12 ± 8.8 days versus 9.4 ± 4.2 days, $P = 0.184$). These preliminary results are encouraging, and prospective, randomized, controlled clinical studies to compare the efficacy, effectiveness, and cost-effectiveness of NPWT to other wound management modalities following cardiac surgery are warranted.

Keywords: retrospective study, postoperative complications, surgical wound infection, anastomosis internal mammary-coronary artery

Index: *Ostomy Wound Management* 2015;61(12):26–30

Potential Conflicts of Interest: none disclosed

According to an analysis of the Society of Thoracic Surgeons[1] adult cardiac surgery database, although available evidence shows bilateral internal thoracic artery (BITA) revascularization provides long-term survival benefits as compared to monolateral internal thoracic artery (ITA) plus saphenous vein bypass, many cardiac surgery centers are reluctant to make it a routine procedure. As shown in an experimental study[2] conducted on 50 fresh specimens of the anterior thorax wall, BITA grafting presents a higher risk for postoperative deep sternal wound infection than single ITA grafting. Sternal complications mainly develop from the distal third of the sternal region, the most ischemic area after ITA harvesting and therefore an ideal acid ambience for bacteria (predominantly *Staphylococcus*) to grow as demonstrated in

Dr. Santarpino is Assistant Professor of Cardiac Surgery; Dr. Gazdag is a medical doctor; Dr. Sirch, Dr. Vogt and Dr. Ledwon are Staff Cardiac Surgeons; Dr. Fischlein is Professor of Cardiac Surgery; and Dr. Pfeiffer is Assistant Professor of Cardiac Surgery, Department of Cardiac Surgery, Cardiovascular Center, Paracelsus Medical University, Klinikum Nürnberg. Nuremberg, Germany. Please address correspondence to: Giuseppe Santarpino, MD, Department of Cardiac Surgery, Cardiovascular Center, Paracelsus Medical University, Klinikum Nürnber, Breslauer Strasse 201 - 90471 Nuremberg, Germany; email: giuseppe.santarpino@klinikum-nuernberg.de.

in vitro cellular cultivation.[3] The use of BITA for standard procedures of surgical revascularization should be the goal of coronary surgery[1]; strategies to reduce sternal complications would enable the widespread application of BITA grafting even in high-risk patients and in the elderly.

In addition, limited blood supply to the thoracic chest wall is a known risk factor for sternal wound complications after coronary artery bypass grafting.[2] A recent meta-analysis with literature review[4] showed a 2.81% incidence of sternal wound infection with use of skeletonized ITA compared to 7.15% in patients who received conventional pedicled ITA harvesting.

The Prevena™ Incision Management System (KCI, Wiesbaden, Germany) is a negative pressure wound therapy (NPWT) product specifically designed for managing surgically closed incisions (see Figure 1a-d). The peel-and-place dressing protects the incision site from bacterial contamination. *In vitro* studies[5] have demonstrated vacuum-assisted closure (VAC) therapy results in microdeformations of open wounds, promoting both cell proliferation in the wound microenvironment and angiogenesis. In addition, using laser Doppler flowmetry, results of a controlled clinical study[6] (N = 20) showed a significant increase in peristernal perfusion with VAC therapy compared to control after ITA harvesting. A porcine sternotomy wound model[7] showed similar results. Up to now, no data have been available on human patients undergoing sternotomy and BITA harvesting.

The aim of this retrospective study was to compare overall outcomes and the incidence of deep sternal wound infection in patients undergoing BITA grafting with or without closed incision management.

Methods

Data for 129 consecutive patients with ischemic heart disease who underwent myocardial revascularization and received BITA grafting according to the surgeon's preference and experience (BITA or ITA plus vein grafts) at the authors' center from February 2003 to October 2014 were retrospectively analyzed. Data abstracted included age, surgical indication (elective, urgent, emergency), Log EuroSCORE and EuroSCORE (institutional surgical risk score for mortality and morbidity, where 0–5 indicates low risk, 5–10 mean risk, 10–15 moderate risk, and >15 high risk), left ventricular ejection fraction, diabetic status, insulin therapy, chronic obstructive pulmonary disease, cortisone therapy, immunosuppressive therapy, combined procedures, number of coronary artery bypass grafts, cross-clamp time, cardiopulmonary bypass time, and procedural time. The postoperative incidence of wound infections and deep sternal wound infections, clinical and radiographic indications of sternal instability, incidence of pneumonia, bleeding events, compliance with the NPWT protocol (eg, patient reports of itching, pain, or pressure in the chest, documented in the medical record), transfusions, amount of chest drainage, and length of hospital stay were recorded for patients who did/did not use NPWT, as well as discomfort with negative pressure; data on discomfort with negative pressure were retrieved from paper records and recorded by the facility's ward doctors. All patients were in accordance with the use of their personal data and provided signed privacy consent.

Ostomy Wound Management 2015;61(12):26–30

Key Points

- The authors abstracted records and compared wound outcomes of 129 patients who underwent bilateral internal thoracic artery grafting.
- The majority (n = 108) of incisions received standard wound care, and the wounds of 21 patients were covered with a negative pressure wound therapy (NPWT) device for 5 days.
- Wound infection rates were 0% the NPWT and 5.6% in the control group, but this difference was not statistically significant and patients in the control group were significantly older and had significantly more surgical risk factors.
- The results of this, and other studies, suggest studies to compare outcomes between various types of dressings following cardiac surgery procedures are needed to help clinicians make evidence-based postoperative care decisions.

Surgical procedures. All procedures were performed through longitudinal median sternotomy by 5 experienced cardiac surgeons. Conventional medication (ie, standard care) comprised adsorbent adhesive gauze dressings (usually Cosmopor E (Paul Hartmann AG, Heidenheim, Germany), 25 cm x 10 cm , changed once daily every day for 5 postoperative days; if excessive bleeding, dirt, and wetness were evident, the dressing was changed more frequently. The wound also was disinfected with an iodine solution. This care continued for the non-NPWT patients. Beginning in August 2013, the NPWT device was used for closed incision management for 21 consecutive patients. Written consent for the use of the NPWT was obtained preoperatively from the patients.

According to standard protocol, the NPWT system is applied under sterile conditions in the operating room immediately after closure of the skin incision with absorbable 4-0 Monocryl sutures (see Figure 1a-d). Following disinfection with an iodine solution, the NPWT system was placed once the skin was dry on the skin surrounding the incision and remained in place at a continuous negative pressure of -125 mm Hg for the first 5 postoperative days, as recommended by the manufacturer (see Figure 2).

Data analysis. Statistical analysis was performed with SPSS 17.0 statistical software (SPSS Inc, Chicago, IL). Continuous and normally distributed data were reported as mean ± standard deviation. Student's *t*-test corrected for Bonferroni's adjustment was used for paired data testing. A P value <0.05

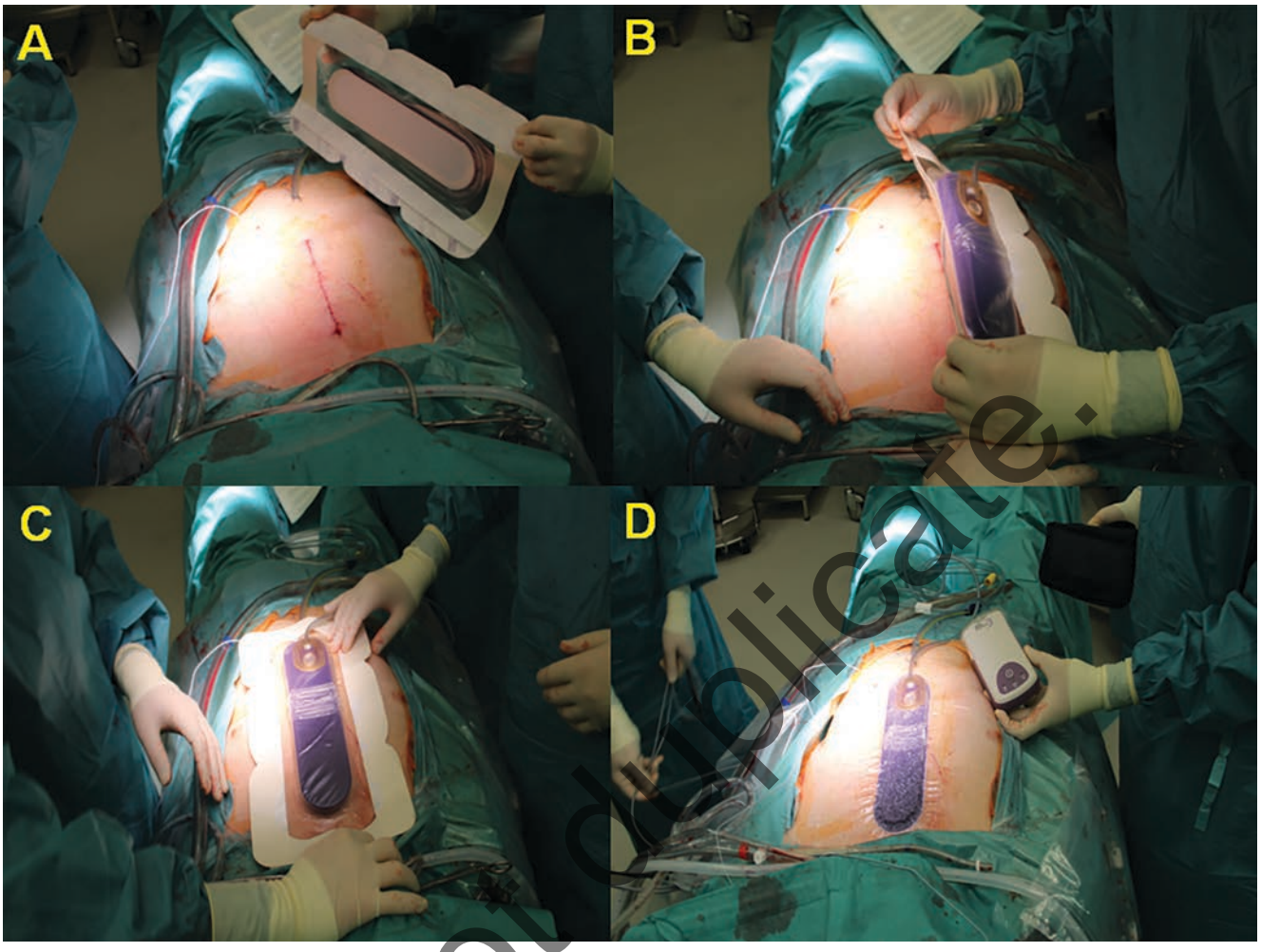

Figure 1. Negative pressure wound therapy use: a) opening and sizing; b) and c): positioning; d) and activation.

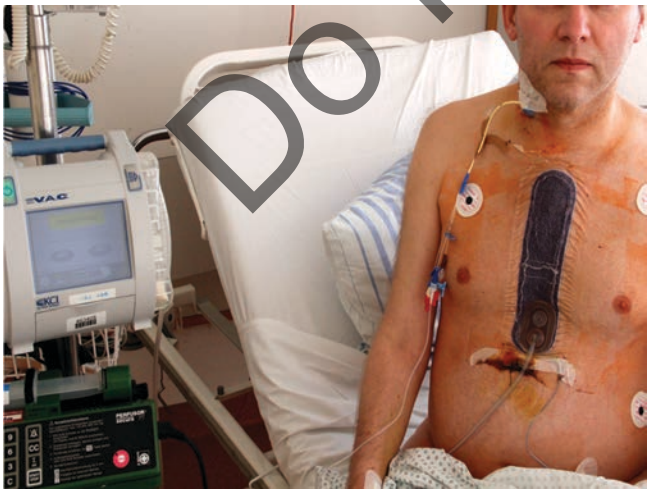

Figure 2. Patient receiving negative pressure wound therapy.

indicated statistical significance. Outcomes data assessed on day 30 postoperatively were the postoperative incidence of wound infections, sternal instability, pneumonia, bleeding events, compliance with the NPWT protocol, transfusions, chest drainage, and length of hospital stay.

Results

The mean age for all patient participants was 60 ± 10.5 years old; 18 patients (13.9%) had diabetes (see Table 1). The NPWT and control group differed significantly in age (55.9 ± 7.6 years versus 60.8 ± 10.8 years, respectively; $P = 0.049$) and EuroSCORE value (2.0 ± 2.3 versus 3.8 ± 2.8, respectively; $P = 0.010$). Other preoperative and perioperative risk factors did not differ significantly between the 2 groups (see Table 2).

No superficial or deep sternal wound infections occurred in the 21-patient NPWT group, but 6 of the 108 patients (5.6%) in the control group developed a deep sternal wound infection. The difference in infection rate was not statistically significant ($P = 0.336$). The incidence of sternal instability was 3.7% (4 of 108) in the control group and 0 (0%) in the

Table 1. Preoperative and intraoperative characteristics of the study population (N = 129)	
Age (years)	60±10.5
Surgical indication	
Elective	85 (65.9%)
Urgent	40 (31%)
Emergency	4 (3.1%)
Log EuroSCORE	3.9±4.7
EuroSCORE	3.5±2.8
Left ventricular ejection fraction (%)	60.5±12.9
Diabetes mellitus	18 (13.9%)
Insulin therapy	7 (5.4%)
Chronic obstructive pulmonary disease	18 (13.9%)
Cortisone therapy	2 (1.5%)
Immunosuppressive therapy	1 (0.8%)
Combined procedures	4 (3.1%)
Mitral valve prolapse	3
Aortic valve replacement	1
Number of coronary artery bypass grafts	2.9±0.8
Cross-clamp time (min)	47.8±20.9
Cardiopulmonary bypass time (minutes)	76.6±31.8
Procedural time (minutes)	193.8±45.8

NPWT group ($P = 0.487$); the 4 patients with instability were not infected, but the 6 persons with deep sternal wound infection were unstable. No suction-related complications or patient discomfort were recorded. One (1) patient in the NPWT group had postoperative bleeding that required removal of the device. In the remaining 20 patients, the device was left in place for 5 days according to standard protocol. One NPWT patient versus 10 control patients underwent rethoracotomy due to bleeding (4.8% versus 9.3%, $P = 0.435$), which translated into a greater need for blood transfusions (0.33 ± 0.7 versus 1.77 ± 3.4 units, $P = 0.056$) and larger chest drainage volume (591.2 ± 346 mL versus 997.8 ± 710 mL $P = 0.012$) in the control group. Hospital stay was longer in the control group, but the difference was not statistically significant (9.4 ± 4.2 days versus 12 ± 8.8 days, $P = 0.184$).

The incidence of pneumonia in the NPWT and control groups (2 and 9 patients, respectively [9.5% versus 8.3%, $P = 0.565$]) and 30-day mortality (0 versus 3 patients [0% versus 2.8%, $P = 0.584$]) were similar in the 2 groups.

Discussion

NPWT may be beneficial to wound healing; it stimulates angiogenesis in the underlying tissue (as demonstrated in a porcine sternotomy wound model[7]), minimizing the risk for sternal wound ischemia due to decreased blood supply to the sternum after BITA harvesting. A recent systematic review and meta-analysis[8] showed BITA grafting was associated with a higher incidence of sternal wound infection compared to ITA. Underscoring this research, deep sternal wound infection requiring revision surgery with staple removal occurred in 3.7% of patients in the control group, but data on superficial wound complications were not recorded in this group. The rate of deep sternal infections was low, considering conventional pedicled ITA harvesting[4] was used. None of the patients in the NPWT group developed a deep infection or were treated for superficial sternal wound infection. None of the outcome variables evaluated were statistically significantly different.

In a biomechanics lab study using finite element analysis, Wilkes et al[9] showed the application of closed incision management with NPWT decreased lateral stress around the incision by 50%, contributing to normalization of tissue forces and closure. In addition, Atkins et al[9] documented (using laser Doppler flowmetry) increased peristernal perfusion in 10 patients who received NPWT at -125 mm Hg for 4 days, compensating for the lower perfusion after ITA harvesting. In a previous retrospective review[10] of 57 adult cardiac surgery patients, the same authors reported no treatments for sternal wound infections were needed.

Although the clinical benefits of closed incision management with NPWT have been reported in a prospective cohort study,[11] results are to be considered preliminary owing to the small sample sizes and the heterogeneity of the study populations. This limitation also applies to the current study, in part because the NPWT group was small and the control group was statistically significantly older and with higher risk for mortality. Ingargiola et al's[12] systematic review of 10 selected studies that investigated the outcomes of 626 incisions on 610 patients who underwent not only sternotomy, but also laparotomy and leg incisions showed possible evidence of a decreased incidence of wound infection with application of incisional NPWT, suggesting the need for further research before recommending NPWT. The results from studies performed in general surgery patients with multiple comorbidities are inconsistent; no benefit from the use of the NPWT system could be demonstrated in a prospective, randomized controlled study[13] comparing NPWT to standard dry dressings on surgical incisions.

A retrospective chart review[14] was performed on 63 consecutive patients with incisions (longitudinal or transverse femoral cutdown for vascular procedures) managed with traditional gauze and 52 consecutive incisions managed with NPWT. The NPWT dressing was found to significantly reduce the incidence of groin wound infection in vascular surgery patients. In a prospective study among a high-risk group of 150 consecutive obese patients undergoing cardiac surgery via median sternotomy, Grauhan et al[15] reported a significant reduction in the rate of wound infection if a negative pressure wound dressing was used. However, no patient included in their prospective study underwent BITA grafting, which makes the present study sample of particular interest. Current preliminary results demonstrating the absence of superficial or deep sternal wound infection in all patients in the

Table 2. Preoperative and intraoperative characteristics by study group

	Study	Control (n = 21)	*P* (n = 108)
Age (years)	55.9±7.6	60.8±10.8	0.049
Surgical indication			0.247
Elective	17 (81%)	68 (63%)	
Urgent	4 (19%)	36 (33.3%)	
Emergency	0	4 (3.7%)	
Log EuroSCORE	2.2±2.6	4.2±5	0.076
EuroSCORE	2.0±2.3	3.8±2.8	0.010
Left ventricular ejection fraction (%)	62.7±7.4	60.1±13.7	0.391
Diabetes mellitus	1 (4.8%)	17 (15.7%)	0.163
Insulin therapy	1 (4.8%)	6 (5.6%)	0.681
Chronic obstructive pulmonary disease	1 (4.8%)	17 (15.7%)	0.163
Cortisone therapy	0	2 (1.9%)	0.7
Immunosuppressive therapy	0	1 (0.9%)	0.837
Combined procedures	0	4 (3.7%)	0.487
Number of coronary artery bypass grafts	2.6±0.7	2.9±0.8	0.111
Cross-clamp time (min)	52.5±17	46.9±21.6	0.262
Cardiopulmonary bypass time (minutes)	83.9±32.4	75.2±31.7	0.254
Procedural time (minutes)	206.2±49	191.4±45	0.175

NPWT group prompted the authors to plan a prospective, randomized multicenter study where the number of patients is appropriate to the number of endpoints and is aimed at confirming or refuting current data.

Limitations

The study design and sample size, especially the sample size of the intervention group, have inherent limitations. In addition, the groups differed significantly in terms of age and EuroSCORE. Patients in the control group were older and had a higher risk for mortality.

Conclusion

Results of a retrospective chart review of 129 patients undergoing BITA showed a lower rate of deep sternal wound infection in patients managed with NPWT (0%, n = 21) compared to patients whose incisions were covered with a conventional gauze medication (3.7%, n = 108). This difference was not statistically significant. Prospective, randomized, multicenter clinical studies comparing the effects of different wound treatment modalities on outcomes of adult cardiac surgery patients undergoing BITA through full sternotomy are needed. ■

References

1. ElBardissi AW, Aranki SF, Sheng S, O'Brien SM, Greenberg CC, Gammie JS. Trends in isolated coronary artery bypass grafting: an analysis of the Society of Thoracic Surgeons adult cardiac surgery database. *J Thorac Cardiovasc Surg*. 2012;143(2):273–281.
2. Berdajs D, Zünd G, Turina MI, Genoni M. Blood supply of the sternum and its importance in internal thoracic artery harvesting. *Ann Thorac Surg*. 2006;81(6):2155–2159.
3. Zhou ZH, Yi QF, Ling YL, Zhou JN, Liu LH, Liu XP. Mineralization and osteoblast response to bioactive glass *in vitro*. *J Med Eng Technol*. 2010;34(4):285–290.
4. Saso S, James D, Vecht JA, Kidher E, Kokotsakis J, Malinovski V, et al. Effect of skeletonization of the internal thoracic artery for coronary revascularization on the incidence of sternal wound infection. *Ann Thorac Surg*. 2010;89(2):661–670.
5. Saxena V, Hwang CW, Huang S, Eichbaum Q, Ingber D, Orgill DP. Vacuum-assisted closure: microdeformations of wounds and cell proliferation. *Plast Reconstr Surg*. 2004;114(5):1086–1096.
6. Atkins BZ, Tetterton JK, Petersen RP, Hurley K, Wolfe WG. Laser Doppler flowmetry assessment of peristernal perfusion after cardiac surgery: beneficial effect of negative pressure therapy. *Int Wound J*. 2011;8(1):56–62.
7. Petzina R, Gustafsson L, Mokhtari A, Ingemansson R, Malmsjö M. Effect of vacuum-assisted closure on blood flow in the peristernal thoracic wall after internal mammary artery harvesting. *Eur J Cardiothorac Surg*. 2006;30(1):85–89.
8. Wu YC, Zhang JF, Ning G, Zhao Q. Bilateral versus single internal mammary artery grafting in patients with severe coronary artery disease and diabetes mellitus: a systematic review and meta-analysis. *J Diabetes*. 2015;Jun 29. [Epub ahead of print].
9. Wilkes RP, Kilpad DV, Zhao Y, Kazala R, McNulty A. Closed incision management with negative pressure wound therapy (CIM): biomechanics. *Surg Innov*. 2012;19(1):67–75.
10. Atkins BZ, Wooten MK, Kistler J, Hurley K, Hughes GC, Wolfe WG. Does negative pressure wound therapy have a role in preventing poststernotomy wound complications? *Surg Innov*. 2009;16(2):140–146.
11. Colli A, Camara ML. First experience with a new negative pressure incision management system on surgical incisions after cardiac surgery in high risk patients. *J Cardiothorac Surg*. 2011;6(Dec 6):160.
12. Ingargiola MJ, Daniali LN, Lee ES. Does the application of incisional negative pressure therapy to high-risk wounds prevent surgical site complications? A systematic review. *Eplasty*. 2013;13(Sep 20):e49.
13. Masden D, Goldstein J, Endara M, Xu K, Steinberg J, Attinger C. Negative pressure wound therapy for at-risk surgical closures in patients with multiple comorbidities: a prospective randomized controlled study. *Ann Surg*. 2012;255(6):1043–1047.
14. Matatov T, Reddy KN, Doucet LD, Zhao CX, Zhan WW. Experience with a new negative pressure incision management system in prevention of groin wound infection in vascular surgery patients. *J Vasc Surg*. 2013;57(3):791–795.
15. Grauhan O, Navasardyan A, Hofmann M, Müller P, Stein J, Hetzer R. Prevention of poststernotomy wound infections in obese patients by negative pressure wound therapy. *J Thorac Cardiovasc Surg*. 2013;145(5):1387–1392.