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PRELIMINARY OUTCOME OF TREATMENT OF POSTOPERATIVE PRIMARILY CLOSED STERNOTOMY WOUNDS TREATED USING NEGATIVE PRESSURE WOUND THERAPY

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Hospital infections, and in particular infections of the surgical site are a common problem of the procedural departments. Due to continuous progress of surgical techniques and patient population getting older with multiple co-morbidities, multidirectional actions need to be taken to avoid these infections or, if they do occur, achieve optimal treatment outcomes. Vacuum wound therapy is one of the directions that has been developed over the recent years.

The aim of the study evaluate wound healing in patients after an off-pump coronary artery bypass grafting procedure, using the internal mammary artery, treated with negative pressure wound therapy system.

Material and methods. This prospective, open label study evaluated healing of postoperative sternotomy wounds after their primary closure with negative pressure wound therapy, using continuous negative pressure of -80 mmHg in 40 patients and 40 patients in a control group in whom conventional dressings were applied in the postoperative period.

Results. The number of patients in whom primary wound healing occurred without complications was significantly higher in the negative pressure wound therapy group versus the control group (χ^2 test =4.50, p=0.0339) and the number of total superficial infections was significantly smaller versus the control group (χ^2 test =5; p=0.0254). Antibiotic therapy was also initiated significantly less often as compared to the group treated with conventional dressings (χ^2 test = 4.11; p=0.0425).

Conclusions. Negative pressure wound therapy after primary wound closure reduces the risk of superficial infections in the population with multiple risk factors of complications in the sternotomy wound healing.

Key words: wound treatment, negative pressure therapy, sternotomy

Nosocomial infections occur at health care institutions worldwide. Their incidence is closely correlated to type of performed diagnostic and therapeutic procedures. Infections of the surgical site are the dominant infections among nosocomial infections at procedural departments. Recently nosocomial infections became a serious problem, both in Poland and worldwide; they are the decisive factor for quality, outcomes and costs of treatment. Infected patients require different management, longer hospitalization, isolation, extended diagnostic workup, use of more expensive medications and medical devices. Infections also affect indirect costs that are difficult to calculate: temporal or complete impairment of physical activity and intellectual skills. Reduction of the number of nosocomial infections will not only reduce costs of treatment, but predominantly will reduce patient mortality and number of disabled persons after the hospitalization. Definitions of Healthcare Associated Infections (HAI) were prepared by a team of experts appointed by European Centre for Disease Prevention and Control (ECDC) in 2009 to homogenize criteria of infection diagnosis in the member states of

European Union and cooperating countries, in the frame of their monitoring. This document includes definitions of all clinical aspects of infection in the inpatient and outpatient clinical practice. The set of definitions was also published in the Official Journal of European Union – volume 55 of 27.09.2012, available on-line: www.eur-lex.europa.eu. This can be the source for verification of a definition of infections adopted at hospitals for the monitoring and registration purposes. The definitions include both clinical criteria as well as laboratory and epidemiological criteria.

Definitions of infections of a surgical site were prepared by experts of European Centre for Disease Prevention and Control (ECDC) to homogenize diagnostic criteria of the infections (1).

Infections of a surgical site can be categorized as:

– superficial infections of a surgical site,
– deep infections of a surgical site,
– organ infections, remote from a surgical site (or of the body cavities).

Over the years various surgical techniques, aimed at reduction of sternotomy wound infections, were evaluated. Various techniques of sternal closure were proposed, including Ribiscek technique, but no statistically significant differences were found as compared to the control group with regard to incidence of sternal dehiscence and mediastinal infections (2). Sternal stabilization using rigid plates was compared to that using wire sternal closure and statistically significantly less common mediastinal infections were found in the group managed with plates (3). Furthermore, use of antibiotic soaked sponge inserted between sternal fragments was evaluated, but no difference was found as compared to the control group with regard to incidence of superficial or deep infections (4). Autologous platelet gel rich in growth factors applied topically on the sternum and in the subcutaneous tissue was analyzed and no difference was found with regard to incidence of infections between the study and control groups (5).

When a tight hydrocolloid dressing applied on the wound for 7 days was used, a significant difference with regard to incidence of superficial and deep infections was found as compared to patients treated with Tegaderm dressings changes in the postoperative period (6). No differences were found as compared to wounds sutured with cutaneous sutures and closed with staples with regard to incidence of wound infections, but total complications (erythema, effusion, necrosis, infection) were more common in the group of wounds managed with staples (7).

As these studies have demonstrated, not all new methods are beneficial with regard to improvement of sternotomy wound healing despite increased costs. Over the recent years studies have been done on a new approach of negative pressure therapy; effectiveness of this therapy in the treatment of chronic and complicated wounds led to expansion of such therapy to the area of treatment of primarily closed wounds with predicted risk of healing problems.

According to Wilkes, use of negative pressure dressing on a primarily closed wound reduces lateral stress in the wound by approximately 50% and changes the direction of stress in such a way that its distribution is similar to distribution of pressures in intact tissues. It provides wound integrity, eliminating free spaces in the subcutaneous tissue between the layers of deep and superficial sutures, reducing the risk of hematoma formation (8). Kilpadi et Cunningham in an animal model evaluated significantly reduced incidence of hematoma formation in wounds treated using negative pressure therapy as compared to the control group, without collection of fluid in the container connected to the system, which can be explained by more extensive elimination from necrotic wound areas through the lymphatic system (9). Systems for the treatment of primarily closed wounds are composed of a tight dressing applied on the wound, overlapping on the skin around the wound, connected via a tube with a small pump generating negative pressure. Discharge aspirated to the dressing is visible and ability to absorb it is also dependent on the size of the dressing.

MATERIAL AND METHODS

The presented study evaluated surgical wound healing in patients after an off-pump coronary artery bypass grafting procedure, using the internal mammary artery, treated with negative pressure wound therapy system. An open label prospective study that was approved by an ethics committee, evaluated 80 patients randomized to 2 groups. Nasal swabs were collected from each patient in the prehospitalization period when eligibility to surgical treatment of coronary artery disease was assessed. All patients were prepared to the surgical procedure according to the procedure of the Department of Cardiac Surgery. After hair removal using a trimmer before the surgical procedure, patients were washed in an antibacterial foam and during the preparations the patients received an antibiotic prophylaxis – cefazolin; its dose was dependent on patient's body weight. Surgical field was disinfected with an alcohol formulation and covered with a surgical iodinated foil. Immediately after the surgical procedure, a dressing system PICO (Smith&Nephew) that contained an absorbing layer, without an additional container for the discharge, using continuous negative pressure (-80 mm Hg), was applied in 40 patients for up to 6 days after the surgery (group P). The dressings were applied according to manufacturer's recommendations; no other agents such as stomy paste were used to seal the system.

A control group was composed of 40 patients in whom conventional wound dressings were used (group C). Conventional dressings were changed daily, while negative pressure dressings were changed on the 2nd or 3rd day and removed on the 5th or 6th day – 1 day before discharge from the hospital and replaced in the event of large exudate or system leakage. The patient follow-up included 6 weeks after the surgical procedure.

Analysis of wound healing in both groups included evaluation of disturbances of postoperative wound healing, using a definition of the surgical site prepared by experts of the European Centre for Disease Prevention and Control (ECDC) and classification according to El Oakley and Wright that categorizes abnormalities of healing of sternotomy wounds into:

1. Dehiscence of wound margins without clinical or microbiological signs of infections.
2. Infections of sternotomy wound with clinical signs or documented by bacteriological tests, including:
   - superficial wound infections – involving subcutaneous tissue,
   - deep wound infections defined as mediastinitis – involving sternum (inflammation of sternal bones), with or without infection of tissues in the retrosternal space.

Statistical analysis

All statistical calculations were performed using a statistical software package StatSoft. Inc. (2011). STATISTICA version 10.0 and Excel spreadsheet. Quantitative variables were characterized using arithmetic mean, standard deviation, median, minimum and maximum (range) and 95% CI (confidence interval), while qualitative variables were presented using numbers and percentages (rates). The Shapiro-Wilk test was used to verify if a quantitative variable was taken from a population with normal distribution. Leven (Brown-Forsythe) test was used to test a hypothesis of equal variances. Significance of differences between the two groups (a model of unrelated variables) was tested using the following tests: t-test (for lack of variance homogeneity – Welch test) or Mann-Whitney U test (if t-test could not be used). Independence χ^2 tests were used for the qualitative variables (using Yates correction for the cell number below 10, with verification of Cochrane conditions, with Fisher's exact test). A significance level $p \leq 0.05$ was used in all calculations.

RESULTS

There were no statistically significant differences between demographic parameters presented in tab. 1 – distribution in both groups was homogeneous – except for the age criterion. The group of patients treated with negative pressure dressing system was significantly older as compared to the control group (Mann-Whitney U test Z=2.02, p=0.0438) which corresponds to a random phenomenon (tab. 1). Nasal swabs were collected from all patients in the period of preparation to the surgical procedure. Table 2 presents distribution of results of microbiology tests. Physiological flora and low-grade Gram positive bacteria predominated; Staphylococci were found in 3 patients (7.5%) in the group P and in 4 patients (10%) in the group C. Table 3 presents perioperative data. Distribution of parameters was homogeneous in both study groups. An average

Table 1. Baseline characteristics of the study group (P) and control group (C)

	P n=40	C n=40	Total n=80	p value
Age				
mean±stand. dev.	66,2±8	62,1±9,1	64,2±8,8	0,0438
range	53-80	41-78	41-80	
median	65	61	63,5	
95%CI	[63,7; 68,8]	[59,2; 65]	[62,2; 66,1]	
Height				
mean±stand. dev.	167,9±8,6	169,6±9,2	168,7±8,9	0,4443
range	143-189	148-186	143-189	
median	169	170	170	
95%CI	[165,1; 170,6]	[166,7; 172,5]	[166,8; 170,7]	
Body weight				
mean±stand. dev.	81,9±16,8	84,0±15,2	83,0±15,9	0,5678
range	51-123	59-127	51,0-127	
median	80,8	80	80,8	
95%CI	[76,6; 87,3]	[79,1; 88,8]	[79,4; 86,5]	
BMI				
mean±stand. dev.	29,1±4,8	29,3±5,2	29,2±5	0,8399
range	19-40	21,9-49	19-49	
median	28,7	28,6	28,6	
95%CI	[27,6; 30,7]	[27,7; 31]	[28,1; 30,3]	
BMI over 30	18 (45%)	17 (42,5%)	35 (43,8%)	0,8217
Sex				
female 1	8 (20%)	9 (22,5%)	17 (21,3%)	0,7846
male 0	32 (80%)	31 (77,5%)	63 (78,8%)	
Hypertension	31 (77,5%)	29 (72,5%)	60 (75%)	0,6056
Diabetes mellitus	9 (22,5%)	11 (27,5%)	20 (25%)	0,6056
COPD	2 (5%)	3 (7,5%)	5 (6,3%)	0,6442
Dyslipidemia	31 (77,5%)	32 (80%)	63 (78,8%)	0,7846
Cigarette smoking	12 (30%)	15 (37,5%)	27 (33,8%)	0,4781
Atherosclerosis	6 (15%)	4 (10%)	10 (12,5%)	0,4990
Chronic renal failure	4 (10%)	4 (10%)	8 (10%)	1
EUROSCORE II				
mean±stand. dev.	1,4±0,9	1,4±1,3	1,4±1,1	0,5348
range	0,5-4	0,5-7,4	0,5-7,4	
median	1,1	1	1	
95%CI	[1,1; 1,7]	[1; 1,9]	[1,2; 1,7]	
Antiplatelet drugs not discontinued	8 (20%)	10 (25%)	18 (22,5%)	0,5923
Elective admission	34 (85%)	34 (85%)	68 (85%)	1
Expedited admission	6 (15%)	6 (15%)	12 (15%)	1

Table 2. Preoperative characteristics of bacteriological data from the study group (P) and the control group (C)

	P n=40	C n=40	Total n=80	p value
Sterile	10 (25%)	8 (20%)	18 (22,5%)	0,5923
Staphylococcus	3 (7,5%)	4 (10%)	7 (8,8%)	0,6924
Other	27 (67,5%)	28 (70%)	55 (68,8%)	0,8094
Scant physiological gram positive flora				

duration of the surgical procedure exceeded 2 hours in both groups.

Intraoperative wound swab was collected at the end of the surgical procedure, before the subcutaneous tissue and skin were closed. Sterile cultures were obtained in 26 patients (65%) in group P and in 25 patients (62.5%) in group C. Scant Gram positive flora dominated

Table 3. Perioperative characteristics of the study group (P) and the control group (C)

	P n=40	C n=40	Total n=80	p value
Duration of the surgical procedure				
mean±stand. dev.	139,1±33,9	136,4±37,2	137,8±35,4	0,6339
range	90-220	75-210	75-220	
median	132,5	130	130	
95%CI	(128,3; 150)	(124,5; 148,3)	(129,9; 145,6)	
Anastomoses				
mean±stand. dev.	1,8±0,8	1,7±0,8	1,8±0,8	0,6476
range	1-3	1-4	1-4	
median	2	2	2	
95%CI	(1,6;2)	(1,5;2)	(1,6;1,9)	
Catecholamines	16 (40%)	13 (33,3%)	29 (36,7%)	0,5388
Intraoperative loss				
mean±stand. dev.	342±159,5	349±189,1	345,5±173,8	1
range	100-800	50-800	50-800	
median	325	300	300	
95%CI	(291; 393)	(288,5; 409,5)	(306,8; 384,2)	
Postoperative drainage				
mean±stand. dev.	610,8±229,3	632,1±266	621,4±247	0,8062
range	190-1 150	240-1 500	190-1 500	
median	605	580	605	
95%CI	(537,4; 684,1)	(547,1; 717,2)	(566,5; 676,4)	
Blood product transfusion	14 (35%)	17 (42,5%)	31 (38,8%)	0,4912
Reoperation	1 (2,5%)	1 (2,5%)	2 (2,5%)	1
Infections other than SSI	4 (10%)	3 (7,5%)	7 (8,8%)	0,6924

among positive culture results (17.5% in group P and 15% in group C). Staphylococci, mainly coagulase-negative species, were grown from 5 patients (12.5%) in group P and in 7 (17.5%) in the control group C. Cultures of the following atypical bacterial flora were also found: Serratia odorifera, Streptococcus agalactiae, Proteus mirabilis or Citrobacter freundi (tab. 4).

In the study population statistically commonly more often uneventful wound healing occurred in patients treated with negative pressure dressings than in patients treated with conventional dressings 37 (92.5%) vs. 30 (75%), p = 0.0339 (tab. 5). Uneventful primary wound healing was found in significantly more patients in the negative pressure dressing system than

Table 4. Perioperative bacteriological characteristics of the study group (P) and the control group (C)

	P n=40	C n=40	Total n=80	p value
Sterile	26 (65%)	25 (62,5%)	51 (63,8%)	0,8161
Scant Gram positive flora	7 (17,5%)	6 (15%)	13 (16,3%)	0,7618
Staphylococcus	5 (12,5%)	7 (17,5%)	12 (15%)	0,5312
Other	2 (5%)	2 (5%)	4 (5%)	1
	Serratia odorifera *Streptococcus agalactiae*	*Proteus mirabilis* *Citrobacter freundii*		

Table 5. Characteristics of wound healing in the study group (P) and the control group (C)

	P n=40	C n=40	Total n=80	p value
Primarily healer wounds without complications	37 (92,5%)	30 (75%)	67 (83,8%)	0,0339
Wounds with healing complications	3 (7,5%)	10 (25%)	13 (16,3%)	

in patients from the control group (χ^2 test = 4.50, p = 0.0339). Furthermore superficial infections were less common as compared to the group treated with conventional dressings (χ^2 test = 5, p=0.0254). Table 6 presents distribution of complications in both study groups.

Treatment of complications required initiation of antibiotic therapy.

In the group of patients treated with negative pressure dressing system, antibiotic therapy was initiated significantly less often as compared to the control group (χ^2 test = 4.11, p=0.0425). Apart from that incidence of signs and symptoms related to postoperative wound healing, such as hematoma, marginal skin necrosis, serous epidermal vesicles resulting from negative pressure and hypertrophic scar, was evaluated in the postoperative period; tab. 7 presents results of this analysis.

Serous vesicles occurred significantly more commonly in the group of patients treated with negative pressure dressing system as compared to the control group (χ^2 test = 5.33, p = 0.0209), while marginal skin necrosis occurred significantly less commonly as compared to the control group (χ^2 test =13.80, p=0.0002).

In one case the negative pressure therapy was discontinued prematurely in group P due to leakage of the PICO system and infection in the lower wound margin. The postoperative wound needed to opening and subsequent secondary suturing. In 1 patient, after a dressing was changed on the 2nd postoperative day, the negative pressure therapy was discontinued due to a hematoma in the subcutaneous tissue along the wound that was absorbed and did not result in any further complications. No case of complete filling of the absorbing layer of the negative pressure dressing was observed. Furthermore, there were no cases of wound with high amounts of discharge. Immediately after the surgical procedure a dressing contained negligible amount of bloody discharge in its absorbing layer which resulted from the fact that it was applied immediately after the wound closure in the operating room.

DISCUSSION

First reports of the use of negative pressure therapy in the treatment of primarily closed

Table 6. Characteristics of complications of wound healing in the study group (P) and the control group (C)

	P n=40	C n=40	Total n=80	p value
Total superficial complications	1 (2,5%)	7 (17,5%)	8 (10%)	0,0254
Superficial wound infections treated only with antibiotics	0 (0%)	4 (10%)	4 (5%)	0,0402
Superficial wound infections that required wound opening	1 (2,5%)	3 (7,5%)	4 (5%)	0,3049
Deep infections	0 (0%)	0 (0%)	0 (0%)	-
Sternal instability	1 (2,5%)	1 (2,5%)	2 (2,5%)	1
Sterile dehiscence of wound margins following suture removal	1 (2,5%)	1 (2,5%)	2 (2,5%)	1
Healing abnormalities resulting from wound ischemia	0 (0%)	1 (2,5%)	1 (1,3%)	0,3204
Wounds with secondary suturing	2 (5%)	5 (12,5%)	7 (8,9%)	0,2490
Sternal refixation	1 (2,6%)	0 (0%)	1 (1,3%)	0,3081

Table 7. Characteristics of signs and symptoms that accompanied wound healing in the study group (P) and the control group (C)

	P n=40	C n=40	Total n=80	p value
Serous vesicles	5 (12,5%)	0 (0%)	5 (6,3%)	0,0209
Marginal necrosis	0 (0%)	12 (30%)	12 (15,2%)	0,0002
Ecchymosis	5 (12,8%)	2 (5%)	7 (8,9%)	0,2214
Hypertrophic scar	3 (7,7%)	7 (18,4%)	10 (13%)	0,1615

wounds appeared in 2009. Recently there have been reports on the use of negative pressure therapy in the treatment of wounds after total knee and hip replacement surgery (10), traumatic wounds in the lower limbs (11), Cesarean's section wounds (12), wounds after vascular surgical procedures in the lower limbs (13), extensive laparotomies (14) and sternotomies (15). Analyses of studies that evaluated use of negative pressure therapy of primarily closed wounds focus on documentation of reduced incidence of infections of postoperative wounds in patients with co-morbidities, with predicted risk of problematic wound healing.

There is a growing body of evidence that use of negative pressure results in reduction of incidence of wound dehiscence. There is no evidence that would suggest requirement for common use of negative pressure therapy in all types of surgical wounds (16). There are literature reports describing treatment of surgical wounds using negative pressure dressing systems applied for 6-7 days, without any mention about changes of the dressings during the therapy. In our study change of a dressing was scheduled for 2^{nd} or 3^{rd} postoperative day to obtain better ongoing control over the wound healing and evaluate possible tissue hematomas along the wound, since in the postoperative period the study subjects received not only low molecular weight heparin, but also antipletelet drugs such as aspirin or clopidogrel. The study group included patients operated due to coronary artery disease who underwent off pump coronary artery bypass grafting procedure.

During the surgical procedure the internal mammary artery (a perfect material for the bypass, with documented longest life span among available bypasses) was dissected. This artery is the main source of blood supply to the sternum and its dissection markedly impairs wound blood supply and can negatively affect the healing process (17). High incidence of documented risk factors of complicated wound healing in both groups must be emphasized, such as: obesity – BMI above 30 in 45% of patients in group P and in 42.5% of patients in group C; diabetes mellitus – 22.5% in group P and 27.5% in group C (18, 19). An average duration of the surgical procedure in both groups exceeded 2 hours. Duration of the surgery exceeding 2 hours is one of the three main risk factors included in the National Nosocomial Infection Surveillance System index (2). Analysis of the above mentioned material supports the use of preoperative nasal swabs.

Epidemiology indicates that approximately 10% of the population are Staphylococcal carriers (21). Patients in the postoperative period, with impairment of immunity, are at particular risk of Staphylococcal infections that may develop not only in the wound. Elimination of carrier status of nasal Staphylococci in the preoperative period has a marked effect on incidence of postoperative wound infections (22). Results of bacteriological tests performed at the end of a long surgery indicate that wound colonization occurs despite adherence to procedures; however this was not always associated with long-term complications, which is related to both patient factors, such as comorbidities or immunity status, and number and virulence of bacteria that colonize the wound. We must emphasize that in cardiac surgery most commonly isolated species from the sternal wounds include various Staphylococcal species: epidermidis, aureus (MRSA and MSSA), warneri, saprophyticus, capitis, cohnii; the most common among them are coagulase-negative Staphylococci. Other Gram positive bacteria such as Enterococcus faecalis, Enterococcus faecium or Gram negative bacteria such as: Pseudomonas aeruginosa, Klebsiella pneumonie, Enterobacter spp. are less common cause of infection of a surgical site.

Fungal infections play a marginal role here (19). Rosemarakis et al. analyzed 377 microbiological samples collected intraoperatively from sternal wounds from 359 patients and isolated pathogens from 80 samples (21.2%), including more than 1 bacterial species in 13 patients. Six different Staphylococcal species were isolated in 68 cases – including cutaneous Staphylococci in 36 (52.9%) of cases (19).

According to literature data, incidence of surgical site infections, a sternotomy wound, ranges widely from 0.3% to even 30% (23). This value is related to characteristics of the study group and its size as well as the period of data duration. Incidence of surgical site infections is significantly lower in very large studies followed-up for a long time. Rate of complications of the wound healing evaluated in the group treated using a conventional dressing is situated in the high part of the interval indicated by the literature data and is significantly higher than in the negative pressure therapy group.

Over the recent years there have been sporadic reports documenting effects of treatment of postoperative wounds using negative pressure dressings in cardiac surgery patients who underwent midline sternotomy; on the other hand number of such reports in orthopedics, plastic surgery and general surgery is higher. In Grauhan et al. enrolled 150 obese patients (with BMI above 30), after various cardiac surgery procedures performed through sternotomy access, to a prospective study; 75 patients received negative pressure dressing therapy of the postoperative wound (-125 mm Hg), while 75 patients received conventional dressings.

A wound infection was diagnosed in 3 of 75 patients (4%) from the continuous negative pressure dressing therapy versus 12 of 75 patients (16%) from the group that received conventional sterile dressings ($p = 0,0266$). A wound infection with Gram positive cutaneous species was found only in 1 patient in whom negative pressure therapy was used versus 10 patients in whom conventional dressings were applied ($p = 0.0090$) (24). Distribution of complications confirms that superficial infections are most common, while no deep infections were found in the study group. Among superficial infections there was a statistically significant difference with regard to superficial skin and subcutaneous tissue infections involving tissue reddening, without wound opening, diagnosed based on the physician experience and knowledge (a diagnostic criterion included in the infection definition according to ECDC) and managed using antibiotic therapy. There are few literature reports and recommendations dealing with this problem. Literature data focus on the problem of wounds that require surgical intervention and guidelines included in a publication dealing with the use of antibiotics in selected skin and soft tissue infections recommended by national consultants for medial microbiology and general surgery indicate that an antibiotic is not required when an infiltrate does not exceed 5 cm and there are no systemic signs and symptoms of infection, such as: fever above 38.5°C and tachycardia over 100 bpm (25). However, therapeutic decisions in such cases should be made on individual basis, considering patient related risk factors of the wound infection and possible complications should the informatory process extend – in sternotomy wounds – the risk of mediastinitis.

Literature data on the negative pressure therapy of primarily closed surgical wounds in other areas from the recent years also focus on effects of reduction of the risk of surgical wound infections.

A review published in 2013 analyzed studies mainly form orthopedics, but also from cardiac surgery and reoperations of abdominal hernias and emphasized that reduction of incidence of surgical site infections (found in 9 of 10 analyzed studies) was the most commonly reported effect of negative pressure therapy of surgical wounds. The second most common problem, dehiscence of wound margins, also occurred less common in patients treated with negative pressure dressings. Reduced collection of serous fluid in the wound and reduced amount of such fluid were reported in two studies included in the review. One of these studies analyzed the problem of skin necrosis but no significant difference was found with regard to incidence of this complication. Increased incidence of skin vesicles was reported in the negative pressure therapy group in one study (26).

These data indicate the importance of individual assessment of the risk of complications of postoperative wound healing in patients. Strict adherence to prophylactic procedures and possible use of additional procedures is required in the high risk group; this was indicated by Neumann and Grzebieniak (26).

Appearance of small, approximately 2 mm serous vesicles that could correspond to epidermal detachment caused by negative pressure, was observed in the negative pressure dressing group. These vesicles were spontaneously absorbed after discontinuation of the negative pressure therapy. Marginal skin necrosis occurred significantly less often in this group of patients which supported the theory that mechanism of beneficial effects of negative pressure therapy was related to improved tissue perfusion. Use of negative pressure systems is convenient for the patient, does not impair his/her physical activity, but can be troublesome in case of irregular wounds, involving skin folds and naturally most areas, since in such instances maintenance of the dressing tightness is difficult. One must remember that the dressing should be applied under sterile conditions to prevent external wound contamination (27).

CONCLUSION

This study indicates that negative pressure therapy of primarily closed wounds improves treatment quality, reduces the risk of superficial infections in a population with multiple risk factors of complications of sternotomy wound healing.

REFERENCES

1. Definicja zakażeń szpitalnych na podstawie decyzji wykonawczej Komisji Europejskiej nr 2012/506/UE z dnia 08.08.2012 r. z komentarzem ekspertów SHL. Biuletyn Stowarzyszenia Higieny Lecznictwa 2013,1(45): 18-19.
2. *Schrimer C, Sommer SP, Bensch M* et al.: Sternal closure techniqes and postoperative wound complications in ederly patients. *Eur J Cardiothorac Surg* 2008; 34: 132-38.
3. *Song DH, Lohman RF, Renucci JD* et al.: Primary sternal plating in high-risk patients prevents mediastinitis. *Eur J Cardiothorac Surg* 2004; 26: 367-72.
4. *Bennett-Guerrero E, Ferguson TB Jr, Lin M* et al.: SWIPE-1 Trial Group. Effect of an implantable gentamycin-collagen sponge on sternal wound infections following cardiac surgery: a randomized trial. *JAMA* 2010; 304: 755-62.
5. *Vang SN, Brady CP, Christensen KA* et al.: Autologous platelet gel in coronary artery bypass grafting: effect on surgical wound healing. *J Extra Corp Technol* 2007; 39: 31-38.
6. *Teshima H, Kawano H, Kashikie H* et al.: A new hydrocolloid dresing prevents surgical site infection of median sternotomy wounds. *Surgery Today* 2009; 39(10): 848-54.
7. *Johnson RG, Cohn WE, Thurer RL* et al.: Cutaneous closure after cardiac operations: a controlled, randomized, prospective comparison of intradermal versus staple closures. *An Surg* 1997; 226(5): 606-12.
8. *Wilkes RP, Kilpadi DV, Zhao Y* et al.: Closed Incision Management With negative Pressure Wound Therapy (CIM): *Biomech Surg Innov* 2011; 25: XX (X): 1-9.
9. *Kilpadi DV, Cunningham MR:* Evaluation of closed incision management with negative pressure wound therapy (CIM): Hematoma/seroma and involvement of the lymphatic system. *Wound Repair and Regeneration* 2011; 19(5): 588-96.
10. *Gomoll AH, Lin A, Harris MB:* Incisional vacuum-assisted closure therapy. *J Orthop Trauma* 2006; 20: 705-09.
11. *Stannard JP, Volgas DA, McGwin G* et al.: Negative pressure wound therapy reduces infection and dehiscence in lower extremity trauma. *J Orthop Trauma* 2012; 26(1): 37-42.
12. *Mark KS, Alger L, Terplan M:* Incisional Negative Pressure Therapy to Prevent Wound Complications Following Cesarean Section in Morbidly Obese Women. A Pilot Study. *Surg Innov* 2013; September 20.
13. *Haghshenasskashani A, Varcoe RL:* A new negative pressure dressing (Prevena TM) to prevent wound complications following lower limb distal arterial bypass. *Br J Diabetes & Vascular Disease* 2011; 11: 21.
14. *Standard JP, Gabriel A, Lehner B:* Use of negative pressure wound therapy over clean, closed surgical incisions. *Wound* 2012; 9 (Suppl.1): 32-39.
15.*Colli A:* First experience with a new negative pressure incision management system on surgical incisions after cardiac surgery in high risk patients. *J Cardiotorac Surg* 2011; 6: 160.
16.*Ingargiola MJ, Daniali LN, Lee ES:* Does the Application of Incisional Negative Pressure Therapy to High-risc Wounds Prevent Surgical Site Complications? A Systematic Review. *Eplasty* 2013 Sep 20; 13: e49. eCollection.
17. *Lepelletier D, Bourigault C, Roussel JC* et al.: Epidemiology and prevention of surgical site infections after cardiac surgery. *Med Mal Infect* 2013; 43(10): 403-09.
18. *Nakano J, Okabayashi H, Haniu M* et al.: Risk factors for wound infection after off-pump coronary artery by-pass grafting: should bilateral internal thoracic arteries be harvested in patients with diabetes? *J Thorac cardiovasc Surg* 2008; 135(3): 540-45.
19. *Rosmarakis ES, Prapas SN, Rellos K* et al.: Nosocomial infections after off-pump coronary artery bypass surgery: freqency, characteristics, and risc factors. *Interact Cardiovasc Thorac Surg* 2007; 6(6): 759-67.
20. *Montewka M, Skrzek A, Plik D* i wsp.: Zakażenia miejsca operowanego – charakterystyka czynników ryzyka, endogennych źródeł zakażenia i metody zapobiegania. *Post Mikrobiol* 2012; 51(3): 227-35.
21. *Samet A, Arłukowicz E, Nowicki R* i wsp.: Nosicielstwo *Staphylococcus aureus* w jamie nosowej jako czynnik ryzyka chorób skóry i zakażeń ogólnoustrojowych. *Przew Lek* 2003; 6(9): 28-33.
22. *Kluytmans JA, Mouton JW, VandenBergh MF* et al.: Reduction of surgical-site infections in cardiothoracic surgery by elimination of nasal carriage of Staphylococcus aureus. *Infect Control Hosp Epidemiol* 1996; 17(12): 780-85.
23. *Borowiec JW:* Infekcje rany dostępu chirurgicznego w kardiochirurgii – „Wizja Zero"; *Kardiochir i Torakochir Pol* 2010; 7(4): 383-87.
24. *Grauhan O, Navasardyan A, Hofmann M* et al.: Prevention of poststernotomy wound infections

in obese patients by negative pressure wound therapy. *J Thorac Cardiovasc Surg* 2013; 145(5): 1387-92.
25. *Hryniewicz W, Kulig J, Ozorowski T* i wsp.: Stosowanie antybiotyków w wybranych zakażeniach skóry i tkanek miękkich. Wydawca: Narodowy Instytut Leków, Warszawa 2012.
26. *Neumann D, Grzebieniak Z:* Zakażenia miejsca operowanego – prospektywne badania własne. *Pol Przegl Chir* 2014; 86(1): 46-56.
27. *Tadisina KK, Chopra K, Sabino J* et al.: Negative Pressure Wound Therapy for Abdominal Wall Reconstruction – publikacja internetowa WWW. Eplasty.com z dnia 13.10.2013

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