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Water Soluble Bone Hemostatic Agent, Was It Effective In Reducing Post-Sternotomy Wound Infection?

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ABSTRACT

Background: The widely utilized Bone Wax (BW) in sealing sternal wound edges is a well-known risk factor for delayed healing and post-sternotomy wound infection, and despite the variety of bone sealants available, we have little data on their effectiveness and safety in sternal wound hemostasis.

Objective: This study aimed to assess effectiveness and safety of water-soluble bone wax (WSW; Ostene® or Tableau Wax®) hemostatic agents as alternative for the ordinary bone wax (BW).

Methods: This study included 323 patients who underwent elective cardiac surgeries via median sternotomy at Kasr-Alainy, Fayoum, and Beniseuf University Hospitals through the period from January 2020 to September 2024. They were divided into two groups: Group A (the control or BW group), which had 165 patients, and group B (the WSW group), which had 158 patients. Postoperative data regarding clinical and radiological signs of wound healing and infection were gathered and analyzed.

Results: The WSW group had a significantly decreased incidence of superficial (12 vs. 25) and deep sternal wound infection (DSWI; 2 vs. 9), as well as a shorter hospital stay (5.8 ± 3.4 vs. 6.7 ± 4.5 days). A trimonthly radiologic follow-up showed that the BW group had considerably worse sternal bone repair than the WSW group ($p < 0.0001$).

Conclusion: Whenever necessary, topical sternal edge hemostasis could be securely and effectively done with water-soluble bone sealants with superior surgical outcomes.

Keywords: Cardiac surgery, Bone hemostatic agent, Wound infection, Sternal wound healing.

INTRODUCTION

Depending on its sticky and sterilizing nature, beeswax has been initially advised as bone marrow sealant in 18th century by Parker and Horsley [(1, 2)], then beeswax has been softened for easier application by adding 12% isopropyl palmitate and/or up to 30% soft paraffin wax [(3, 4)].

This formula is insoluble and can stay undigested for years [(5)], resulting in a local giant cell chronic inflammatory reaction (wax granuloma) [(6)], impaired osteogenesis with delayed wound healing [(7, 8)], secondary infection (DSWI) [(9)], and potentially lethal mediastinitis [(10)].

Thus, it is preferable to reduce the use of BW through good surgical practice or by using a safer alternative. Water-soluble bone waxes (WSW) are derived from alkylene oxide block copolymers that pass unmetabolized through renal excretion within 48 hours of application, ensuring proper hemostasis, while preventing local inflammatory responses that may impede osteogenesis and pave the way for bacterial superinfection [(11, 12)].

WSW has certified its efficacy and safety in craniofacial and spinal orthopedic procedures [(13, 14)]. However, little information is available about its use in procedures requiring sternotomy.

In this study, we aimed to investigate the efficacy and safety of WSW as a bone hemostat on sternal bone healing following sternotomy incisions in cardiothoracic surgery.

PATIENTS AND METHODS

Study design: This study included 323 patients who underwent elective cardiac-thoracic surgeries requiring sternotomy with the use of a bone hemostat at Kasr-Alainy, Fayoum, and Beniseuf University Hospitals over the last four years. Patients were divided into two groups based on the type of hemostat used: Group A (BW group; 165 patients) and group B (WSW group; 158 patients). Following surgery, data regarding clinical and radiologic signs of sternal bone healing or complications were collected and examined.

DEFINITIONS

Deep sternal wound infection (DSWI): Its diagnosis was settled on presence of at least one of the following criteria [(15, 16)]:

(1) An organism is isolated from cultured mediastinal tissue or fluid.

(2) Evidence of mediastinitis seen during surgery.

(3) One of the following clinical conditions: Chest discomfort, sternal instability, or fever (>38 °C) in conjunction with either purulent discharge from the mediastinum or the isolation of an organism from blood or mediastinal drainage.

Radiologic signs for sternal wound using non-contrast–enhanced CT scan:

CT images of the sternum were obtained on a tri-monthly basis, including the manubrium, body, and xiphoid process, during a short period with inspiratory hold. We used a 64-channel multislice CT scanner with a sharp filter, 2-mm slice thickness, 1-mm slice

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increment, and a field of view ranging from 100 to 250 mm to standardize a single imaging technique.

The following grades of healing were used to define each patient's stage of sternal bone healing [17, 18]:
Grade 0: No healing where there was no defined blurring of callus formation between the 2 sternal edges.
Grade 1: Partial healing (Central gap) where there was visible callus formation or blurring between the 2 sternal edges.
Grade 2: Complete healing where there were total bone healing with well-calcified sternotomy line and the gap was erased.

Exclusion criteria: We excluded patients with **expected impaired healing** (such as prolonged corticosteroid therapy, uncontrolled diabetic, morbid obesity conditions, coronary artery bypass grafting needing bilateral mammary harvestmen and patients with **bleeding tendency** (such as chronic atrial fibrillation, or concurrent vascular illnesses requiring antiplatelet or anticoagulant treatment).

Study endpoints:
- **The primary endpoints:** Sternal bone healing and DSWI.
- **Secondary endpoints:** Post-operative ICU and hospital stays, the quantity of postoperative bleeding through mediastinal drains, and the amount of blood products utilized during surgery.

Ethical approval: The study protocol was accepted by The Ethics Council of Fayoum University Hospitals in Egypt [Ethical approval number: R 406]. Each patient gave a written, informed consent to the operation. The study adhered to the Helsinki Declaration throughout its execution.

Statistical analysis and sample size:
Sampling method: With an alpha error of 5%, a 95% confidence level, and an 80% power sample, the Medcalc 19 program was used to determine the appropriate sample size population (323 patients) [Equations are provided by **Machin *et al.*** [19]].
Data analysis: Categorical data were presented as percentages, while continuous data were presented as mean and standard deviation or median with the interquartile range. Statistical significance was defined as P values ≤ 0.05, and all reported P values were two-sided. A qualified statistician assisted with all statistical analyses.

RESULTS

A total of 323 patients (160 females) were divided into two groups: Group A (The control group of 165 patients using BW) and group B (Including 158 patients in whom we used WSW). Our sample's mean age was 51.88 ± 9.456 years old. There was no significant difference between both groups regarding all demographic and clinical baseline characteristics (p > 0.05) (Table 1).

Table (1): Demographic and preoperative parameters

Preoperative parameter	Group A (165)	Group B (158)	P Value
Age (Years)	57.6 ± 7.5	56.8 ± 8.5	0.1251
Male sex	90 (54.54%)	73 (46.20%)	0.2910
Body Mass index (BMI; Kg/m^2)	26.6 ± 3.9	26.3 ± 3.7	0.4791
Chronic obstructive pulmonary disease	40 (24.24%)	35 (22.15%)	0.6570

No statistically significant differences were found regarding type of intervention, operative time (162 ± 52.9 vs. 158 ± 42.64 minutes) and amount of bone hemostat used (1.6 ± 0.63 vs. 1.58 ± 0.63 packs) (Table 2).

Table (2): Intraoperative parameters

Intraoperative parameter	Group A (165)	Group B (158)	P Value
Type of intervention			
CABG	**58** (35%)	**55** (34.81%)	**0.9715**
MVR	**43** (26.06%)	**40** (25.32%)	**0.8793**
AVR	**30** (16.16%)	**33** (20.89%)	**0.2743**
DVR	**18** (10.91%)	**17** (10.76%)	**0.9655**
Adult ASD	**10** (6.06%)	**8** (5.06%)	**0.6927**
Supra-coronary conduit.	**6** (3.64%)	**5** (3.16%)	**0.8123**
Operative time (minutes)	162 ± 52.94	158 ± 42.64	**0.4563**
Amount of wax used (number of packs opened)	1.6 ± 0.63	1.58 ± 0.63	**0.7757**

CABG; Coronary artery bypass graft, MVR; Mitral valve replacement, AVR; Aortic valve replacement, DVR; Double valve replacement, ASD; Atrial septal defect.

Regarding our primary endpoints, DSWI afflicted 7 patients (2.16%), with 6 of them belonging to the BW group, indicating a statistically significant difference (P = 0.0496). When we compared stages of sternal bone healing in each group, we discovered that the WSW group healed significantly better at 3 and 6 months (P = 0.0022 and P = 0.0186 respectively).

Focusing on the secondary endpoints, we observe statistically less postoperative bleeding (480 ± 97 vs.

530 ± 120 ml), fewer blood products used (63 (39.87%) vs. 89 (53.64%)), and shorter ICU (2.75 ± 0.54 vs. 3.55 ± 0.68 days) and hospital stays (6.45 ± 1.33 vs. 7.45 ± 1.53 days) among WSW patients compared to those in the BW group (Table 3).

Table (3): Postoperative parameters

Postoperative parameter	**Group A (165)**	**Group B (158)**	**P Value**
Primary Endpoints: DSWI	**1** (0.61%)	**6** (3.80%)	**0.0496**
Sternal Bone Healing			
○ 3 months postoperatively	2.34 ± 0.81	2.6 ± 0.7	**0.0022**
○ 6 months postoperatively	2.75 ± 0.55	2.87 ± 0.33	**0.0186**
Secondary Endpoints:			
• Total Mediastinal tube drainage (ml)	530 ± 120	480 + 97	**0.0001**
• Number of blood-products used during surgery	**89** (53.94%)	**63** (39.87%)	**0.0115**
○ Plasma	69 ± 3.08	54 ± 2.76	< **0.0001**
○ Packed RBC	20 ± 3.81	9 ± 2.06	< **0.0001**
• Postoperative ICU (days)	3.55 ± 0.68	2.75 ± 0.54	< **0.0001**
• Postoperative hospital stays (days)	7.45 ± 1.53	6.45 ± 1.33	< **0.0001**

DISCUSSION

Ordinary bee wax (BW), which is utilized as a bone sealant in the majority of cardiothoracic procedures that need a sternotomy, is a well-known contributor to sternal wound dehiscence and DSWI, which significantly worsens surgical outcomes [20, 21]. BW's insoluble nature inhibits osteogenesis and triggers a local inflammatory response, facilitating bacterial superinfection with eventual wound gapping and mediastinitis [22].

In this study, we sought to evaluate the safety and efficacy of Water-Soluble Wax (WSW) products through assessing bone healing and the incidence of deep sternal wound infection (DSWI) in patients who underwent sternotomy and required bone sealant. No statistically significant differences were found regarding type of intervention, operative time (162 ± 52.9 vs. 158 ± 42.64 minutes) and amount of bone hemostat used (1.6 ± 0.63 vs. 1.58 ± 0.63 packs).

In 2014, **Vestergaard *et al.*** [23] found higher risk of sternal wound infection and poor healing among patients using BW but not reaching statistically significant level. Their results agreed with data published by **Bitkover *et al.*** [24] and **Prziborowski *et al.*** [9]**.** In contrary, **Bruce *et al.*** [25] and **Bhatti and Dunning** [20] approved higher incidence of sternal bone infection and delayed healing on using the BW.

In our study, when we compared stages of sternal bone healing in each group, we discovered that the WSW group healed significantly better at 3 and 6 months (P = 0.0022 and P = 0.0186, respectively). Ordinary bee bone wax frequently generates foreign-body and giant cell reactions, as well as long-term inflammation and osteolysis, whereas water-soluble wax dissolves in urine within 48 hours and produces no local inflammatory changes, resulting in faster wound healing [26].

In our study, we observed statistically less postoperative bleeding (480 ± 97 vs. 530 ± 120 ml), fewer blood products used (63 (39.87%) vs. 89 (53.64%)), and shorter ICU (2.75 ± 0.54 vs. 3.55 ± 0.68 days) and hospital stays (6.45 ± 1.33 vs. 7.45 ± 1.53 days) among WSW patients compared to those in the BW group.

Tavlaşoğlu *et al.* [27] found that WSW was significantly more effective than BW in reducing sternal edge bleeding, infection rates, and the need for blood and blood product units postoperatively. This is consistent with our findings, which showed statistically significant improved bone repair and lower infection rates in the WSW group compared to the BW group.

Elmorsy *et al.* [28] on the other hand, looked at how well oxidized regenerated cellulose (ORC) worked as a soluble form of sternal bone sealants. They discovered that using both BW and electrocautery had the same effect as WSW in stopping sternal bone intramedullary bleeding. Patients who were treated with ORC also had less infection, but the difference wasn't significant.

CONCLUSION

The high cost of WSW and its need to be softened with warm saline prior to application may be considered a drawback. However, its usage should be advised in patients at high risk of poor sternal bone healing or wound dehiscence, such as diabetes, osteoporosis, morbid obesity, prolonged corticosteroid therapy, and patients who underwent CABG using bilateral mammary grafts.

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