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UDC 617.54
DOI – https://doi.org/10.14300/mnnc.2024.19023
ISSN – 2073-8137

THE OUTCOMES OF EMPLOYING A SPECIALIZED ALGORITHM FOR FORECASTING AND COMPREHENSIVE PREVENTION OF PURULENT-DESTRUCTIVE DISEASES AFFECTING THE CHEST WALL IN CARDIOTHORACIC SURGERY

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РЕЗУЛЬТАТЫ ПРИМЕНЕНИЯ СПЕЦИАЛИЗИРОВАННОГО АЛГОРИТМА ПРОГНОЗИРОВАНИЯ И КОМПЛЕКСНОЙ ПРОФИЛАКТИКИ ГНОЙНО-ДЕСТРУКТИВНЫХ ЗАБОЛЕВАНИЙ ГРУДНОЙ СТЕНКИ В КАРДИОТОРАКАЛЬНОЙ ХИРУРГИИ

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The article offers a view of the outcomes of an integrated approach employed for forecasting and preventing purulent-destructive diseases of the chest wall (PDDCW) pertaining to cardiothoracic surgery. The data obtained through the study point to the high effectiveness of the approach in question while allowing for a lower PDDCW incidence (up to 10 %) in patients going through the postoperative period and to shorten the hospitalization period.

Keywords: thoracic surgery, purulent surgery, cardiovascular surgery, sterno-mediastinitis, osteomyelitis, result

Представлены результаты комплексного подхода в прогнозировании и профилактике гнойно-деструктивных заболеваний грудной стенки (ГДЗГС) в кардиоторакальной хирургии. Полученные в исследовании данные показали высокую эффективность предложенного подхода, позволяя снизить частоту развития ГДЗГС у пациентов в послеоперационном периоде до 10 % и сократить сроки госпитализации.

Ключевые слова: торакальная хирургия, гнойная хирургия, сердечно-сосудистая хирургия, стерномедиастинит, остеомиелит, результат

For citation: Andreev D. Yu., Aidemirov A. N. The outcomes of employing a specialized algorithm for forecasting and comprehensive prevention of purulent-destructive diseases affecting the chest wall in cardiothoracic surgery. *Medical News of North Caucasus.* 2024;19(2):103-107. DOI – https://doi.org/10.14300/mnnc.2024.19023

Для цитирования: Андреев Д. Ю., Айдемиров А. Н. Результаты применения специализированного алгоритма прогнозирования и комплексной профилактики гнойно-деструктивных заболеваний грудной стенки в кардиоторакальной хирургии. *Медицинский вестник Северного Кавказа.* 2024;19(2):103-107.
DOI – https://doi.org/10.14300/mnnc.2024.19023

ADBAC – Alkyldimethylbenzylammonium chloride
BMI – body mass index
CT – computed tomography
DM – diabetes mellitus
IHD – ischemic heart disease
PDDCW – purulent-destructive diseases of the chest wall
SM – sterno-mediastinitis

Purulent-destructive diseases of the chest wall (PDDCW) imply a pathological condition of the chest wall bone frame, featuring the destruction of the bone tissue and bearing signs of affecting the surrounding tissues, too [1]. The treatment of PDDCW is an essential part of purulent surgery. The development of the said condition is associated with pus-inducing processes close to vital organs and with the destruction of the thoracic skeleton bone structure. As a result, the already existing purulent-inflammatory disease turns into the development of a life-threatening condition.

As of today, PDDCW accounts for 1.1 % to 10 % of the entire number of cardiothoracic surgeries [2–4]. The fatal outcome rate, meanwhile, reaches 30 % [5, 6]. In most cases, patients come from specialized surgical in-patient wards where extensive and – most frequently – traumatic interventions involving the heart and the mediastinum are performed [7, 8].

Despite the ongoing effort to modify and improve the surgical techniques for chest-related interventions and develop whole sets of promising preventive measures, the incidence of PDDCW remains high [9, 10].

This study aimed to evaluate a specialized algorithm for forecasting and comprehensive prevention of PDDCW in cardiothoracic surgery.

Material and Methods. The present study was carried out on the premises of the Purulent Surgery Department and the Cardiac Surgery Department of the Stavropol Regional Clinical Hospital, with both somatically healthy and comorbid patients (with two or more diseases/syndromes in one patient related to each other by a common pathogenetic mechanism or coinciding in time involved [11].

The study involved 200 patients scheduled for surgery on chest organs, who were divided into two groups. Group I (the main group) consisted of 100 patients treated from 2023 to 2024; they received their forecasting subject to the algorithm we had developed and were given respective comprehensive preventive measures. Group II (the control group) included 100 patients treated between 2022 and 2023. These patients were given conventional preventive measures.

Based on the ICD-10 coding, the following pathologies were attributed to PDDCW: «Osteomyelitis» (M86) and «Diseases of the mediastinum, not elsewhere classified» (J98.5), which is used for sterno-mediastinitis (SM).

The inclusion criteria were age over 18, the patient's consent to join the study, planned chest surgery (possibly previous chest surgery), and comorbidity.

The non-inclusion criteria were age under 18, the patient's refusal to join the study, current infectious (non-purulent destructive) disease of any etiology and localization, and allergic response to the antibacterial drugs or skin antiseptic components to be used.

Group I had 68 males and 32 females, whereas the sex-based division in Group II was 81 versus 19 males and females, respectively. The average age in Group I was 58.7±14.3, the same indicator in Group II being 60.7±9.9 (p=0.92). The details above show that the two groups shared similar characteristics. Figure 1 contains the data on the age criteria in both groups (subject to the WHO classification).

Employing the analysis of the PDDCW occurrence following thoracic and cardiac surgical interventions and relying on the data obtained from globally available sources [12, 13], we developed a method for PDDCW forecasting. The algorithm is a questionnaire (Table 1; Certificate of software official registration #2023619221 of May 05, 2023) [14].

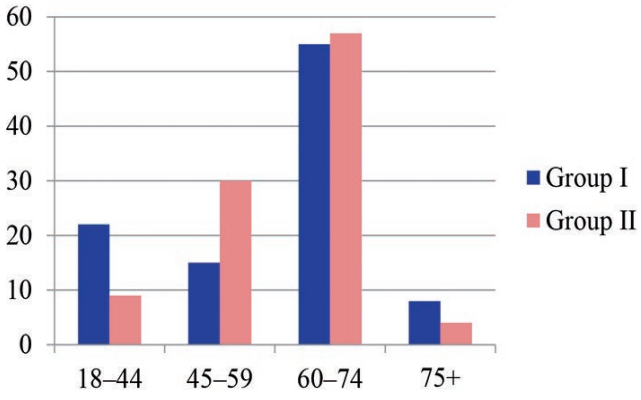

Fig. 1. Age-based distribution

Each item in the questionnaire offered one or more answer options, all summed up in a numerical result. The results evaluation for possible PDDCW development are to be interpreted as follows: 6–9 points – low risk; 10–17 points – average risk; 18 points or above – high risk.

We designed a comprehensive prevention structure based on the results for possible PDDCW development forecasts.

At the preoperative stage, all the patients in Group I underwent a preventive antibiotic procedure with Cefazolin (1 g, intravenously streamed, 1 hour before the surgery) [15].

The next stage of preventive measures related to PDDCW was treating the operating field. For Group I, we used the Sanimed-Express polycomponent skin antiseptic (Lysoform-SPb, Russian Federation) triple, with a 1-minute exposure between the treatments [16]. For Group II, a complex iodine & polyvinylpyrrolidone compound (Povidone-iodine) was used, triple, with a 30-second exposure between the treatments [17, 18]. Throughout the study, the patients had wash-offs taken from the operating field before and after the field treatment.

The wash-off from the operating field was done with sterile gauze wipes (5x5 cm) soaked in a neutralizer. After sampling, the napkin was placed in tubes containing saline solution and glass beads and shaken for 5 minutes. The liquid was in-depth seeded in 2 Petri dishes with meat-peptone agar (0.5 ml each) and in 2 test tubes with 0.5 % sugar broth (1 ml each). The cultures were incubated for 48 hours (temperature – 37 °C).

For intraoperative PDDCW prevention, the patients in Group I had their surgical wounds treated with argonoplasmic coagulation, with scanning movements on an ONYX-A 400 W device (Fotek, Russian Federation), where the coagulating plasma arc current ≥20A, voltage 20–35V, working gas – argon [19] was used for the purpose.

At the surgical wound suturing stage, the wound surface and edges were rinsed with an antibacterial solution of Cefazolin to stop any possible contamination of the operating field [20].

Table 1

Algorithm for PDDCW forecast development in cardiothoracic patients «Prognosis sheet for PDDCW in patients with thoracic pathology in the surgical department with background information»

Indicators	Score
1) Age group, subject to the WHO classification *(only one option to be selected)*	
18–44	1
45–59	2
60–74	3
75+	4
2) Gender *(only one option to be selected)*	
Female	1
Male	2
3) Body Mass Index (BMI) *(only one option to be selected)*	
<16 (significant deficit)	3
16–18.4 (deficit)	2
18.5–24.9 (standard)	1
25–29.9 (pre-obesity)	1
30–34.9 (obesity, Degree I)	2
35–39.9 (obesity Degree II)	3
>40 (obesity, Degree III)	4
4) Type of surgical intervention *(only one option to be selected)*	
Planned	1
Urgent	2
Emergency	3
5) Frequency of surgical intervention on chest (period – calendar year) *(only one option to be selected)*	
Primary	1
Repeated	2
6) History of purulent-destructive diseases of chest wall (PDDCW) *(only one option to be selected)*	
No	0
Yes	1
7) Duration of surgical intervention *(only one option to be selected)*	
Up to 45 min	1
45 min to 90 min	2
Over 90 min	3
8) Concomitant pathologies *(multiple options are allowed)*	
• lung diseases (COPD, occupational diseases, previously transmitted infectious and other diseases involving lung damage)	1
• metabolic diseases (diabetes mellitus, lipid metabolism disorders, etc.)	1
• blood diseases (anemia, coagulation disorders, etc.)	1
• vascular diseases of extremities (varicose veins, phlebitis, etc.)	1
• diseases of cerebral vessels (stroke)	2
• cardiovascular diseases (coronary heart disease, atherosclerosis, hypertension, etc.)	3
• current oncological issues (treatment to be done at time of surgery)	4
• generalized infections (tuberculosis, HIV infection, etc.)	4
• immunosuppressive conditions	4
9) Comorbidity: *(only one option to be selected)*	
No	0
Yes	1
10) Compensation for concomitant pathology/comorbidity at time of surgery: *(only one option to be selected)*	
Yes	0
No	1
Total	

The statistical processing was done using the STATISTICA 10.0 (StatSoft, USA) and Excel 2016 (Microsoft, USA) software. To test the null hypothesis concerning the homogeneity of patients in the two groups, the differences were analyzed based on the Student's t-criterion and the Mann – Whitney U-criterion for quantitative signs, depending on compliance with the respective conditions for their application (distribution normality and variance equality for the t criterion). The case of $p<0.05$, the differences were considered statistically significant.

Results and Discussion. At the beginning of the study, all the patients of Group I underwent the PDDCW forecasting procedure employing the questionnaire. The average score in Group I was 14.7, indicative of the average risk of developing complications within the postoperative period. The average score for males was 14.8±3.2 (min = 9, max = 22), whereas for females it was 14.4±3.7 (min = 8, max = 26).

During the treatment results evaluation, given the use of our prediction algorithm and improved methods for PDDCW prevention, 55 cases of complications were identified in Group II (55 % of the total number of the patients in the group) versus 10 cases in Group I (10 % of the total number of the patients in the group), which offers a dynamic difference of –81.82 % if compared to Group II. Figure 2 contains a graphic image of the situation.

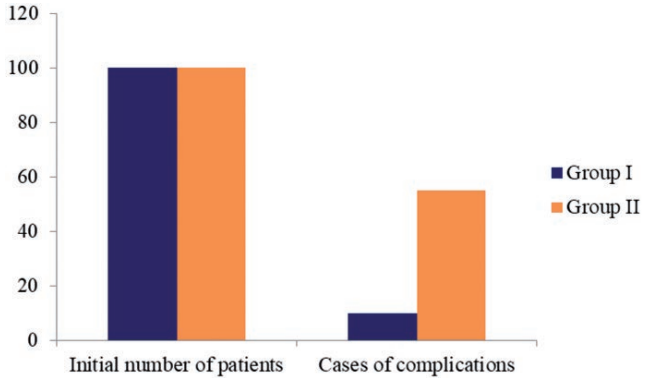

Fig. 2. Number of complications in Group I and Group II

Notable also is that the hospitalization period with postoperative complications in Group I was significantly shorter ($p<0.01$) than in Group II (17.9±1.6 and 28.1±2.5 postoperative days, respectively).

Examination of the wash-offs from the operating fields revealed gram-positive and gram-negative pathogens. Several cases were found to contain a mixed infection; few isolated gram-positive and gram-negative pathogens were detected in the cultures taken following the treatment due to the pathogens' high resistance to the antiseptic components. Table 2 offers a comparative analysis of the outcomes.

Table 2

Operating field treatment comparison outcomes (%)

Operating field treatment stage	Group I	Group II	Statistical significance
Prior to treatment	76.4±4.2	77.1±8.2	0.058
Following treatment	0.11±0.06	0.9±0.1	<0.01

In the postoperative period, seven days following the surgery up until discharge from the hospital, patients with a high PDDCW risk (18 points or above, based on the algorithm) underwent computed tomography (CT) examination focusing on the chest bone skeleton, thus aiming to identify any possible bone destruction foci. This examination was performed subject to the clinical recommendations used for the surgical treatment of patients with postoperative mediastinitis and osteomyelitis affecting the sternum and the ribs [21].

An analysis of the data reported by Russian and international experts suggests the effectiveness of employing the forecasting algorithm jointly with improved methods for comprehensive prevention of PDDCW in patients after they have undergone respective surgical chest interventions [22–25].

Upon a comparative assessment of the results obtained using the PDDCW forecasting algorithm and improved comprehensive prevention, we can safely claim that the number of postoperative complications in Group I was lower if compared with Group II (Mann – Whitney criterion, $p<0.0001$). A shorter length of hospitalization, in turn, leads to lower financial costs of treatment.

A. S. Dyumin and G. G. Khubulava et al. offer independent accounts of the need to forecast PDDCW after surgical interventions involving the chest [26, 27]. M. M. Abakumov, in his work, pointed at a high level of respective mortality, which can be reduced through the developments available nowadays [28].

Conclusion. The algorithm we have developed to forecast potential PDDCW occurrence in the postoperative period in patients in cardiothoracic surgery allows for a reliably accurate generation of preliminary data regarding potential complication development and makes it possible to assess the risk of such complications.

The study described above serves as proof of the fact that the PDDCW prevention strategy employed in the group mentioned above of patients ensures a reliable qualitative reduction in the rate of postoperative complications while offering a dynamic difference (–81.2 %), if compared to the approach conventionally accepted in cardiothoracic surgery.

Disclosure: The authors herewith declare no conflict of interest.

References

1. Andreev D. Yu., Ajdemirov A. N. Purulent-destructive diseases of the chest wall: diagnosis, treatment, prevention. Modern science: actual problems of theory and practice. *Natural and technical sciences*. 2023;11:131-136. https://doi.org/10.37882/2223-2982.2023.11.02
2. Siciliano R. F., Medina A. C. R., Bittencourt M. S., Gualandro D., Uezum K. K. [et al.] Derivation and validation of an early diagnostic score for mediastinitis after cardiothoracic surgery. *The Journal of Infectious Diseases*. 2020;90:201-205. https://doi.org/10.1016/j.ijid.2019.09.010
3. Malathi L., Das S., Nair J. T. K., Rajappan A. Chest wall reconstruction: success of a team approach-a 12-year experience from a tertiary care institution. *Indian Journal of Thoracic and Cardiovascular Surgery*. 2020;36(1):44-51. https://doi.org/10.1007/s12055-019-00841-y
4. Blüher M., Brandt D., Lankiewicz J., Mallow P. J., Saunders R. Economic analysis of the European healthcare burden of sternal-wound infections following coronary artery bypass graft. *Front Public Health*. 2020;8:557-555. https://doi.org/10.3389/fpubh.2020.557555
5. Hamaguchi R., Shekar P. S., Johnson J. A., Orgill D. P. Current management of sternal wounds. *Plastic and Reconstructive Surgery*. 2021;148(6):1012-1025. https://doi.org/10.1097/PRS.0000000000008510

6. Attia R. Q., Katumalla E., Cyclewala S., Rochon M., Marczin N. [et al.] Do in-hospital outcomes of isolated coronary artery bypass grafting vary between male and female octogenarians? *Interactive Cardiovascular and Thoracic Surgery*. 2021;34(6):958-965. https://doi.org/10.1093/icvts/ivab281
7. Kaspersen A. E., Nielsen S. J., Orrason A. W., Petursdottir A., Sigurdsson M. [et al.] Short- and long-term mortality after deep sternal wound infection following cardiac surgery: experiences from SWEDEHEART. *European Journal of Cardio-Thoracic Surgery*. 2021;60(2):233-241. https://doi.org/10.1093/ejcts/ezab080
8. Petrosyants S. V., Aidemirov A. N., Rovenskih D. N., Shevchenko S. P., Vladimirova O. V. [et al.] The study of the dynamics of the periprosthetic capsule formation after mastectomy and non-flapped reconstructions of the mammary gland in patients. *Medical News of North Caucasus*. 2023;18(4):390-393. https://doi.org/10.14300/mnnc.2023.18092
9. Falkner F., Thomas B., Haug V. Comparison of pedicled versus free flaps for reconstruction of extensive deep sternal wound defects following cardiac surgery: A retrospective study. *Microsurgery*. 2021;41(4):309-318. https://doi.org/10.1002/micr.30730
10. Perrault L. P., Kirkwood K. A., Chang H. L. A prospective multi-institutional cohort study of mediastinal infections after cardiac operations. *The Annals of Thoracic Surgery*. 2018;105(2):461-468. https://doi.org/10.1016/j.athoracsur.2017.06.078
11. Chris van W., François G. S. Comorbidity and guidelines: conflicting interests. *The Lancet*. 2006;367(9510):550-551. https://doi.org/10.1016/S0140-6736(06)68198-1
12. Vladimirova O. V., Lavreshin P. M., Minaev S. V., Muravyev A. V., Tsvetkov V. O. [et al.] Strategy for scar-prevention healing of traumatic and burns wounds. *Medical News of North Caucasus*. 2023;18(2):148-151. https://doi.org/10.14300/mnnc.2023.18032
13. Pradeep A., Rangasamy J., Varma P. K. Recent developments in controlling sternal wound infection after cardiac surgery and measures to enhance sternal healing. *Medicinal Research Reviews*. 2021;41(2):709-724. https://doi.org/10.1002/med.21758
14. Andreev D. Yu., Ajdemirov A. N., Bajramkulov M. D., Belyaev I. V. Prognosis sheet for purulent-destructive complications of the chest wall (PDDCW) in patients with thoracic pathology in the department of surgical. Certificate of state registration of a computer program № 2023619221. Available at: https://www1.fips.ru/iiss/document.xhtml?faces-redirect=true&id=bbd5f66c3a-4623f51a30d56060e844b8
15. Andreev D. Yu., Ajdemirov A. N. The leading methods of prevention and treatment of purulent-destructive diseases of the chest wall. *Issues of expertise and quality of medical care*. 2024;1:5-8.
16. Instruction on the use of disinfectant «Sanimed-E`ks-press». 2015 [electronic resource]. Available at: https://makidez.ru/files/_____-.pdf.
17. Lazar H. L., Salm V. T., Engelman R. [et al.] Prevention and management of sternal wound infections. *The Journal of Thoracic and Cardiovascular Surgery*. 2016;152:962-972.
18. Aygun F., Kuzgun A., Ulucan S. [et al.] The protective effect of topical rifamycin treatment against sternal wound infection in diabetic patients undergoing on-pump coronary artery bypass graft surgery. *CVJ of Africa*. 2014;25(3):96-99. https://doi.org/10.5830/CVJA-2014-008
19. Xasanov A. G., Nurtdinov M. A., Nigmatzyanov S. S., Sakaev R. Sh., Karamova R. F. The experience of using plasma streams in the complex treatment of chronic osteomyelitis. *Surgery*. 2010;10:59-61.
20. Tünay H. Evaluation of surgical antibiotic prophylaxis. *Health Sciences Quarterly*. 2023;3(1):43-47. https://doi.org/10.26900/hsq.1908
21. Clinical recommendations for surgical treatment of patients with postoperative mediastinitis and osteomyelitis of the sternum and ribs. 2014 [Electronic resource]. Available at: https://docs.yandex.ru/docs/view?url=yabrowser %3A %2F %2F4DT1uXEPRrJRX-lUFoewruM54rLg-r0tofFye5augEJuv4r1Tfrm11_cOkrA-j1HtfNTnbZkJ7MFUy2pt-Fp9_-TarWqepgwjjJMcwX-gqDtrHJySWC4YaxtICR_vTC7D3mjgrn_to9j-PcND-178DcIrw %3D %3D %3Fsign %3D7CfhFNdF3IgcqF1H-GqcsHkrU6uN7jaRodi-fh__fCtw %3D&name=Sternomediastinit.docx
22. Andreev D. Yu., Ajdemirov A. N. The main approaches to the prevention and treatment of sternal infection. *A young scientist*. 2024;5(504):46-49.
23. Petrosyants S. V., Aidemirov A. N., Rovenskih D. N., Vladimirova O. V., Sidorov S. V. [et al.] Non-flapped breast reconstructions options using silicone endoprothesis after subcutaneous mastectomy for cancer. *Medical News of North Caucasus*. 2021;16(1):97-103. https://doi.org/10.14300/mnnc.2021.16025
24. Al-Ebrahim K. E. Management of deep sternal wound infection: complete sternal osteomyelitis. *Heart Surg. Forum*. 2020;23(3):281-284. https://doi.org/10.1532/hsf.2805
25. Elsayed R. S., Carey N. J., Cohen R. G. Early onset of deep sternal wound infection after cardiac surgery is associated with decreased survival: A propensity weighted analysis. *Journal of Cardiac Surgery*. 2021;36(12):4509-4518. https://doi.org/10.1111/jocs.16009
26. Dyumin A. S. Modeling of osteomyelitis of the sternum in an experiment. *Prospects of science and education*. 2018;1(31):266-268.
27. Hubulava G. G., Shihverdiev N. N., Fogt P. R. [et al.] Predicting the likelihood of developing a sternal infection in cardiac surgery patients. *Grekov's Bulletin of Surgery*. 2018;177(1):11-15.
28. Abakumov M. M. Diagnosis and treatment of purulent mediastinitis is a special chapter in the history of surgery. *Pirogov Russian Journal of Surgery*. 2019;3:105-110. https://doi.org/10.17116/hirurgia2019031105

Received 05.10.2023

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