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Grouping Patients after Surgery by Minimum Sum of Squares Clustering Method

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Abstract

In this paper for the first time the clustering method is applied in surgery post-operational complications. We first collect data after surgery of 825 patients in hospital in Serbia, taking into account 3 their attributes. Among 825 patients, 32 of them had the occurrence of dehiscence laparotomy. We analyze the risk of taking surgery based on clustering patient in groups, taking into account the presence of infection, diabetic and neoplastic disease. The minimum sum-of-squares model is used and tested by k-means heuristic and Variable neighborhood search based method. It appears that the method used is very important, i.e., VNS based heuristic provides significantly better results. Some interesting conclusions are also derived.

Keywords: Clustering method, Surgery, Laparotomy, Grouping Patients

Introduction

Dehiscence of laparotomy is a sudden partial or complete opening or tearing wounds, or the formation of cracks in the surgical wound sewinged [1]. Complete wound disruption with evisceration of abdominal organs requires urgent re-intervention. It occurs most often during the first week after surgery. It occurs in 0.5% to 3% of operated patients [2]. Dehiscence of laparotomy is accompanied by high morbidity and mortality that ranges up to 40%. The process of wound healing is a highly complex and dynamic set of cellular, biochemical and immunological processes, which depends on several factors. Infection of the surgical wound is one of the most important risk factor for dehiscence of laparotomy. Gastrointestinal surgery, emergency surgery, prolonged surgical time, and are associated with an increased risk of surgical wound infection. Wound infection defined as purulent secretion from the wound contents, regardless of the bacteriological findings [3]. It occurs in up to 15% of treated patients [4-6]. Diabetes is characterized by atherosclerosis, microangiopathy, disorder of Hb dissociation and decreased chemotaxis and phagocytosis. Dehiscence of laparotomy is more common in patients with neoplastic diseases. Reasons are not entirely clear. It is assumed that the protein and calories lost in the tumor also has a premise that tumor cells secrete substances that interfere with wound healing [7]. The survey aims to determine the effect of the presence of infection, diabetes and malignant disease of the emergence of dehiscence of laparotomy.

Methods

Statistical tests

Research is organized by type of retrospective prospective studies that have analyzed the following data as risk factors: The presence of infection, diabetes and neoplastic diseases of dehiscence of laparotomy of 825 operated patients at the department of general surgery of Niš in 2016th and 2017th year. Complications dehiscence of laparotomy was found in 32 patients. Statistical sample size is determined by the statistical methodology to meet the basic principle of representativeness. The normogram was used to determine the optimal sample. In this paper, results are presented in tables and graphically. The statistical analysis using the methods of descriptive statistics (mean, standard deviation), parametric tests (Student's t-test) and nonparametric Chi square test. For statistical analysis we used the software package SPSS 14.0 and the imaging table and a Microsoft Office Word 2003.

Minimum sum-of-squares clustering

One of mostly used criterion for clustering is Minimum Sum-of-Squares (MSS), where all entities are placed in n-dimensional Euclidean space and their dissimilarities calculated as squared distances in Rn. The number of clusters m is given in advance. The objective is to make groups of entities such that the total sum of squared distances within each group or cluster is minimum.

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Table 1: Comparison of k-means and VNS heuristics in clustering n=825 patients into m groups.

M	K-means			VNS		
	f	# of entities	Time	f	# of entities	Time
2	327	{ 32, 793}	0 .2	327	{32,793}	0.5
3	171.4	{32,81,712}	0 .4	171.4	{32,206,587}	1.2
4	104.5	{4,28,81,712}	0.7	104.5	{32,112,157,524}	1.7
5	92.07	{2,4,26,81,712}	0.9	76.71	{32,49,63,157,524}	2.0
6	68.85	{2,10,17,20,201,575}	1	50.5	{32,38,49,51,157,498}	2.3
7	66.94	{2,4,17,26,26,201,549}	1.1	33.04	{20,32,39,49,51,137,498}	2.3
8	45.31	{5,6,12,20,26,26,181,549}	1.4	24.34	{12,25,26,32,44,51,137,498}	2.9

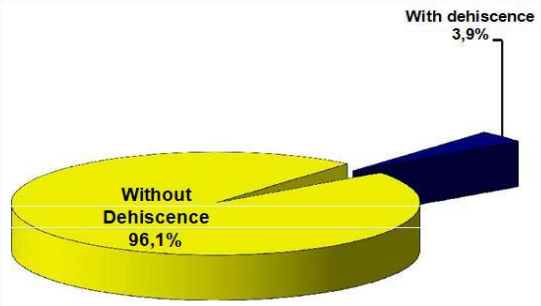

Figure 1: Number of dehiscence of the total number of respondents.

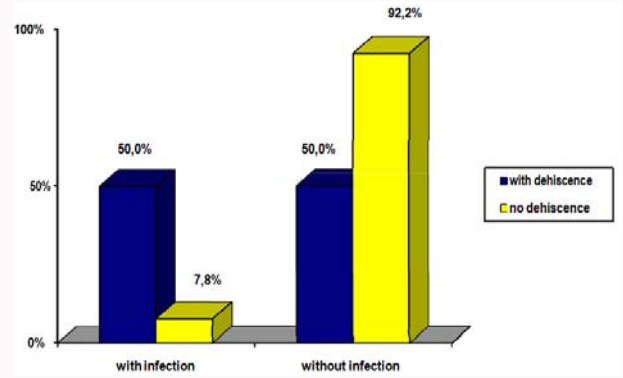

Figure 2: Impact of infection on the occurrence of dehiscence of laparotomy.

It appears that minimizing the intra group distances is equivalent to maximizing the square distances among entities from different groups [8]. This property makes MSS most popular criterion since it measures in the same time homogeneity and separation. Moreover, MMS may be equivalently presented as the problem of minimizing the square distances from each entity to its own cluster center or centroid [8].

Since MMS problem is NP hard [8], there are many heuristics already appeared in the literature? The most popular heuristic is so called k-means method. It alternatively solves allocation of entities to their closest centroid and finding the corresponding centroid of each cluster. Although being very popular due to its simplicity, the results obtained by k-means sometimes are very far from the global optimum [8]. That is the reason why there are many heuristics that are trying to improve precision of k-means algorithm. One among them is J-means and Variable Neighborhood Search (VNS) based heuristic [8].

In this paper we presented data of 825 patients in 3-dimensional space. As mentioned earlier, those three attributes (or risk factors) are: infection, diabetes, the presence of neoplastic diseases on the occurrence of dehiscence of laparotomy. All three are considered as binary variables. In the next section we will analyze the results obtained by both k-means and VNS heuristics.

Results

Statistical tests

Dehiscence of laparotomy occurred in 3.9% of patients and 32 patients of the total 825 respondents (Figure 1). There is a statistically significant relationship between dehiscence of laparotomy and infections (χ^2=62,024; p<0.01). Infection was significantly more prevalent in patients with dehiscence of laparotomy. Of 32 patients with peritoneal them 16 or 50% had an infection and the 793 patients without infection, dehiscence had all 62 of them, or 7.8% (Figure 2). In the group of patients with dehiscence of laparotomy is more people with diabetes than in the control group, but this was not statistically significant (χ^2=0.491; p>0.05). Patients with diabetes were 26 of them, or 4.2% of the group of persons with dehiscence of laparotomy, and 596 patients with diabetes were in the group of patients without dehiscence of laparotomy or 95.8%. In patients with dehiscence without diabetes was 3.0% or 6 patients, and without dehiscence of laparotomy and 197 patients without diabetes or 97.0% (Figure 3).

There is a statistically significant relationship between dehiscence of laparotomy and neoplastic diseases (χ^2=42,196; p<0.01). Of the 18 patients with neo plastic disease, 6 of them had dehiscence of laparotomy or 33.3%, and 12 patients h ad no dehiscence of laparotomy, or 66.7%. Without malignant disease were 26 patients with dehiscence of laparotomy, or 3.2% and 781 patients without dehiscence of laparotomy or 96.8% (Figure 4). Of the 32 patients with dehiscence of laparotomy them 6 or 18.75% had a malignant disease and the 793 patients without dehiscence of 12 or 1.51% had a malignancy.

Clustering results

In Table 1 we report results obtained by two heuristics for minimum sum-of-squares clustering: k-means and VNS. The first the number of desired clusters are given. The second line gives the value of the objective function, while in column 3 we report the number of entities in each cluster obtained by k-means. The next 3 columns report the same values given by VNS. It appears that both methods keep 32 patients with dehiscence laparotomy in the same cluster. The difference in results starts after m=5, where the total sum of squares are 92.07 and 76.71 obtained by k-means and VNS respectively. Moreover, VNS keeps the 32 patients in the same cluster up to m=8. This means that not only the clustering model is important but also the method used.

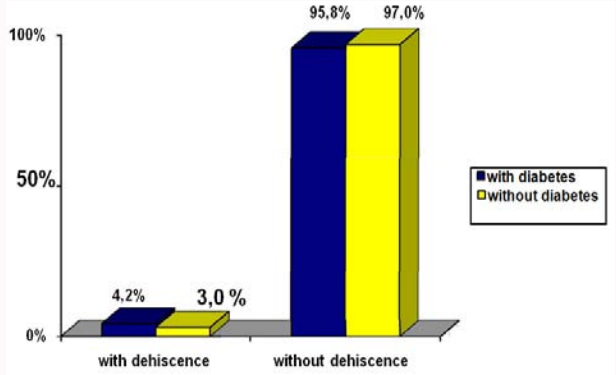

Figure 3: Effect of diabetes on the occurrence of dehiscence of laparotomy.

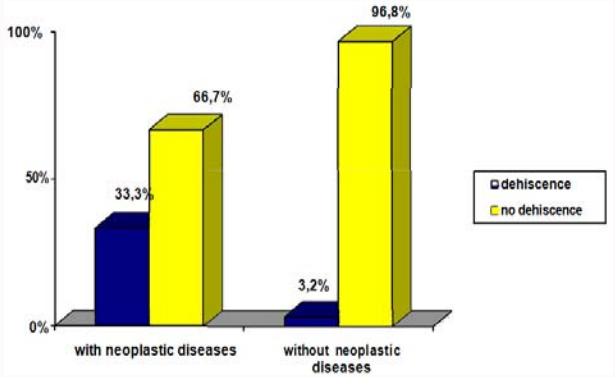

Figure 4: The presence of neoplastic diseases on the occurrence of dehiscence of laparotomy.

Some observations regarding results reported at Table 1 are:

1. Clustering models and methods may be successfully used in medicine in general and more particularly in Surgery in parallel with statistical tests;

2. Hypotheses may be automatically derived, e.g., the 32 patients with dehiscence of laparotomy are kept in the same group with up to 8 clusters;

3. Results obtained by clustering techniques are more rich in a sense that they provide more information to practitioners: relations between clusters, introduction of many patient's attributes in analysis, etc;

4. The clustering method used may play a significant role in understanding the final results, i.e., VNS based heuristic outperform significantly k-means heuristic for number of clusters grater or equal to 5.

Discussion

In this section we first discuss our results obtained by statistical tests and then comment on their relations with clustering.

Despite major advances in the understanding of the process of wound healing physiology, surgical techniques and the application of modern technologies and materials in surgery, the percentage of impaired healing laparotomy is still high. Dehiscence of laparotomy occurs in approximately 3% of patients. In a retrospective study by Rodriguez-Hermosa JI et al. [9] from Spain in 57 patients or 0.45% of the total 12,622 patients who had undergone laparotomy occurred in dehiscence of laparotomy. The Cracow study Kenig J et al. [10] and associates with dehiscence of laparotomy occurred in 56 patients or 2.9% of our patients. Our results show that dehiscence of laparotomy was present in 3.9% of patients and 32 patients of the total 825 respondents. Preoperative preparation is an important stage in the treatment of surgical patients and the adequacy of preoperative depends on result of the operation, the incidence of complications and mortality of patients. It is necessary that all the general condition of the patients preoperatively stabilized and carry a minimum of anesthesia and surgical preoperative whenever the patient's condition allows [11]. Both studies confirm recent views that chronological age of more than sixty years ago, in itself is not a contraindication for extensive operations in abdominal surgery [7,12-14]. Far more important are the parameters that determine the biological age of the patient: The patient's general condition and ability to care for oneself (performance status), nutritional status (Seltzerov index), as well as the risk of anesthesia estimated ASA score [12]. Infection is extremely destructive effect on the wound healing process by increasing the production of cytokines and proteases, which disrupt the synthesis of fibroblasts, and the stability of the wound [15]. Our study confirms this claim, because patients with the presence of infection, far more frequent respiratory failure. 50% of patients with dehiscence of laparotomy occurred of infection. In Germany, a study was done by Fleischer GM and all, dehiscence of laparotomy occurs in 5% to 10% of patients with infection [16]. In our study, the percentage impact of infection on the occurrence of dehiscence much higher. In India's study from Rajindra Hospital in Patiala only 4 (8%) of our wound dehiscence patients were diabetics. These patients were given insulin [17]. Of all diabetics in our study does not receive any insulin therapy, and because I have this complication less pronounced. In patients with diabetes, dehiscence of laparotomy occurs more frequently but it is not statistically significant ($p>0.05$). The five year prospective observational study was performed 7,224 operations in 4,197 patients in South Australia, 196 had diabetes patients (4.7%). The incidence of 2 patients with diabetes appeared [18] and do not differ from those without dehiscence ($p=90$), which is concordant with our study. In our study group of patients with dehiscence of laparotomy is more people with diabetes than in the control group, but this was not statistically significant ($\chi^2=0.491$; $p>0.05$). Patients with diabetes were 26 of them, or 4.2% of the group of persons with dehiscence of laparotomy, and 596 patients with diabetes were in the group of patients without dehiscence of laparotomy or 95.8%. In patients with dehiscence without diabetes was 3.0% or 6 patients, and without dehiscence of laparotomy and 197 patients without diabetes or 97.0%. The presence of malignant disease is accompanied by intense tumor metabolism, malnutrition and disorders of absorption, all of which can disrupt the normal wound healing process and therefore the more frequent occurrence of dehiscence. Many drugs, anti-tumor and anti-cancer drugs affect the various stages of wound healing, particularly in cell division [14]. Statistically there is a strong association between dehiscence of laparotomy and neoplastic diseases ($\chi^2=42,196$; $p<0.01$). Neoplastic diseases, in our material had 6 patients with dehiscence of laparotomy, or 33.3%. A study worked in South Korea in 1987 to 2004 was included 8033 patients. Dehiscence of laparotomy occurred in 9.3% of treated patients with cancer [19]. Aksamija G et al. [20] who worked on the study in Clinic for abdominal surgery in Sarajevo in 1998 to 2002 dehiscence after laparotomy surgery colon cancer from 439 patients were observed in 10 patients, or 2.27%.

Comparing the results with the results of international studies in

this paper comes to the conclusion that our results are not worse than the results of the world's health task.

Conclusion

Dehiscence of laparotomy occurs in less than 5% of patients. In the presence of infection in patients with neoplastic diseases, dehiscence of laparotomy is common. Dehiscence of laparotomy is less common in people with diabetes. The analysis of these three risk factors, the surgeon can identify patients at high risk and to take all measures that prophylaxis his disposal.

In this paper we introduce for the first time a clustering technique in analyzing risk factors on the occurrence of dehiscence laparotomy. We show that minimum sum-of squares clustering model is well suited for this purposes. Moreover, we show that some hypotheses may be automatically derived, instead of assuming their validity and then testing in usual statistical way. Future work may consist of further implementation of other clustering paradigms in surgery, as well as in medicine in general.

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