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The Analysis of Anesthesia Methods Used in Cesarean Section Through Data Mining Techniques

Sezaryen Ameliyatında Kullanılan Anestezi Yöntemlerinin Veri Madenciliği Yöntemleri İle İncelenmesi

Gizem Dilan Boztaş[1], Ersin Karaman[2], İbrahim Hakkı Tör[3]

[1]Digital Transformation Office, Karadeniz Technical University, Trabzon, Turkey
[2]Faculty of Fine Arts, Department of Visual Communication Design, Visual Communication Design Art Major, Ankara Hacı Bayram Veli University, Ankara, Turkey
[3]Department of Anesthesiology and Reanimation, Erzurum Regional Training and Research Hospital, University of Health Sciences, Erzurum, Turkey

Abstract

Aim: The aim of this study is to examine and analyze new patterns of cesarean section anesthesia types and prediction performances of decision trees with data mining techniques.

Material and Method: Classification and clustering analysis were performed to analyze the data of 300 patients. Gini algorithm and C5.0 algorithm were applied to the data set with 24 parameters. These algorithms were also applied to the 16-parameter data set obtained after preprocessing. The estimation performances obtained were compared according to the accuracy criterion. Then, clustering analysis was applied to the 24 and 16 parameter data sets with the K-prototype algorithm.

Results: The study revealed that the prediction success of the Gini algorithm was determined as 96.61%, and the prediction success of the pruned decision tree obtained by the Gini algorithm was 94.91%. The prediction success of the C5.0 algorithm was determined as 98.87%.In the clustering analysis performed with the K-prototype algorithm, the number of clusters was determined as 4 and 5 for both data sets, based on expert opinion, and important patterns were observed with these cluster numbers.

Conclusion: As a result of the study, it was revealed that the C5.0 algorithm had the highest performance with an accuracy rate of 98.87As a result of the cluster analysis, it was concluded that the age of the patients, the duration of the operation, the type of previous anesthesia, the number of previous cesarean sections, the fear of anesthesia and the previous surgical operations were effective on the type of anesthesia in cesarean section cases.

Keywords: Data science, anesthesia types, cesarean section, k-prototype, classification

Öz

Amaç: Bu çalışmanın amacı, sezaryen anestezi tiplerinin yeni örüntülerini ve karar ağaçlarının tahmin performanslarını veri madenciliği teknikleri ile incelemek ve analiz etmektir.

Gereç ve Yöntem: 300 hastanın verilerini analiz etmek için sınıflandırma ve kümeleme analizi yapıldı. 24 parametreli veri setine Gini algoritması ve C5.0 algoritması uygulanmıştır. Bu algoritmalar, ön işlemeden sonra elde edilen 16 parametrelik veri setine de uygulanmıştır. Elde edilen tahmin performansları doğruluk kriterine göre karşılaştırılmıştır. Daha sonra K-prototip algoritması ile 24 ve 16 parametreli veri setlerine kümeleme analizi uygulanmıştır.

Bulgular: Çalışma, Gini algoritmasının tahmin başarısının %96.61, Gini algoritması ile elde edilen budanmış karar ağacının tahmin başarısının ise %94.91 olduğunu ortaya koydu. C5.0 algoritmasının tahmin başarısı %98,87 olarak belirlenmiştir. K-prototip algoritması ile yapılan kümeleme analizinde uzman görüşüne dayalı olarak her iki veri seti için küme sayısı 4 ve 5 olarak belirlenmiş ve bu küme sayıları ile önemli örüntüler gözlemlenmiştir.

Sonuç: Çalışma sonucunda C5.0 algoritmasının %98,87 doğruluk oranı ile en yüksek performansa sahip olduğu ortaya çıkmıştır. Kümeleme analizi sonucunda ise hastaların yaşı, operasyon süresi, önceki anestezi tipi, önceki sezaryen sayısı, anestezi korkusu ve önceki cerrahi operasyonların sezaryen olgularında anestezi türü üzerinde etkili olduğu kanısına varılmıştır.

Anahtar Kelimeler: Veri bilimi, anestezi türleri, sezaryen, k-prototip, sınıflandırma

Corresponding *(İletişim)*: İbrahim Hakkı TÖR, Department of Anesthesiology and Reanimation, Erzurum Regional Education and Research Hospital, University of Health Sciences, Erzurum, Turkey
E-mail *(E-posta)*: ibrahimhakkitor@gmail.com
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INTRODUCTION

Information technologies enable us to easily collect data in a great number of fields. However, data is meaningless unless it is processed and transformed into information. Therefore, data mining has an important role in discovering information in large amounts of data. It is an undeniable fact that solutions to problems produced by data mining provide significant benefits for every field. This also applies to medicine and healthcare.It is possible to define data mining as "the discovery of statistically significant patterns, relationships, changes, irregularities, rules and structures in data ".[1]

Research by WHO (World Health Organization) demonstrates that cesarean deliveries are increasing globally. Currently, cesarean section accounts for more than 1 in 5 (21%) births worldwide. It is estimated that this rate will increase in the next ten years and will reach 29% of all births by 2030. As in the rest of the world, the cesarean section rate is higher than the normal birth rate in Turkey.[2] According to OECD (Organization for Economic Cooperation and Development) data, 584 out of 1000 live births were performed by cesarean section in Turkey in 2021.[3] This situation has made the choice of anesthesia type in cesarean section operations more important.

Data mining studies focus on descriptive or predictive functions. The purpose of prediction-based functions is to build a prediction model using existing data, and the purpose of definition-based models is to identify patterns among data by observing available data, and to identify features and characteristics of different datasets[4] "Classification" and "Regression" are predictive models. "Clustering" "Association Rules" and "Sequential Models" are some examples of descriptive models.

The aim of this study is to determine whether there are new patterns about cesarean section anesthesia types decided by anesthetists using data mining techniques and to compare the prediction successes of decision tree algorithms in this regard.

This part of the study consists of two sub-sections. Firstly, data mining and machine learning studies in health sciences are mentioned. Secondly, the studies on the selection of anesthesia type in the cesarean section are explained.

Data mining methods are used in gynecological and obstetric studies, as in many branches of health. For example; Senthilkumar et al. in the study of it is aimed to determine risk factors for low birth weight by using data mining methods.[5] Similarly, Mehbodni et al. classified fetal health using machine learning methods.[6] In the studies of Abdar et al.[7] and Begum et al.[8] applied the data mining methods for internal diseases studied. Topaloğlu et al. used C5.0 and J48 as classification methods on infectional disease related data.[9] Moreover, Şatır et al., applied ID3, C4.5, CART and artificial neural network (ANN) methods on glokom data set.[10]

The selection of the most appropriate general or regional anesthesia method for cesarean sections takes into account various factors, such as the urgency of the procedure, the patient's preference, the patient's current health status and any comorbidities, as well as the expertise and experience of the surgeon and anesthetist.[11,12] Regional anesthesia is often preferred over general anesthesia due to lower maternal mortality rates associated with it compared to general anesthesia.[13,14] The safety of general anesthesia in cesarean section has improved greatly due to technological advances and advances in emergency algorithms. Maternal deaths due to anesthesia have gradually decreased, but it has been observed that, relatively speaking, the risk of maternal death in general anesthesia applications is higher than in regional anesthesia applications, although it is not statistically significant.[15] The decision on which anesthesia method to use depends on whether the case is urgent or elective.

Berrin et al., stated that the rate of spinal anesthesia in elective C / S increases because spinal anesthesia has a positive effect on the APGAR score.[16] In another study Okafor et al., suggested that spinal anesthesia was performed in 40% of emergency cases.[13]

When the indication for emergency cesarean section is realized by the obstetrician, the guidelines recommend consulting the anesthesiologist and making the evaluation at the earliest period.[17] According to the British and Irish Society of Anesthesiologists and Obstetrics and Anesthesiologists, the time allowed for preoperative anesthesia preparation and administration of spinal anesthesia is 30 minutes after an emergency cesarean section is reported to the anesthesiologist unless the life of the mother and baby is in danger.[18] Classification of urgency in cesarean sections is shown in **Table 1**.

Table 1. The urgency classification in cesarean sections[16,17]

	Identification (as soon as the operation decision is made)
Category 1	The lives of the mother or fetus are in danger; the operation is required as soon as possible.
Category 2	Some factors threaten the life of the mother or fetus, but there is no level of urgency that requires an immediate operation.
Category 3	Preterm birth is required, but the life of the mother and fetus is not in danger
Category 4	Delivery by cesarean can be planned for an appropriate time for the mother and birth team (planned elective)

In this classification, the time elapsed between cesarean delivery and the delivery of labor (Decision- To-Delivery Interval (DDI): in terms of maternal and infant health) is supposed to be under 30 minutes. In these cases, if cesarean delivery is not performed, the lives of the mother and fetus are at serious risk. General anesthesia is preferred in Category 1 cases. Guidelines and references for cases in Category 2, such as antepartum hemorrhage and progression of labor, suggest that this DDI duration should be <75 minutes, the anesthetic selection depends on the clinical situation of the mother and fetus at the time of the cesarean decision. Early membrane rupture in which maternal and fetus lives are not threatened, and non-progressive cases of fetal distress are not included in Category 3. In this category, the choice of anesthesia and the pace of the procedure performance are

determined by the clinical situations of the mother and fetus at the time of the cesarean decision. It has no difference from those in elective cesarean sections. Category 4 covers elective cesarean cases.[19, 20]

MATERIAL AND METHOD

In the model phase, C 5.0 and Gini algorithms as classification methods, k-prototype as clustering method used .For this purpose, data were collected from 300 participants who gave birth via cesarean section in a maternity hospital. Before data collection, the ethics committee approval was obtained from Atatürk University Medical Faculty (Date: 15/02/2018, Decision No: 2018/46). The data were collected via a data collection form including 24 parameters. While 239 of those participants were anaesthetized with spinal methods, remaining 61 of them were anaesthetized with general anesthesia method. Before the parameter selection, the data set is composed of the parameters specified in **Table 2**.

Table 2. Data set before parameter selection

Data Set 1	Parameters	Abbreviations
Demographic parameters of the patients		
	Age	AGE
	Height	
	Weight	WEIGHT
Parameters related to the pregnancies of the participants		
	Number of pregnancies	
	Gestational week	G.W
	Number of previous cesarean sections	CS. NUMBER
Parameters related to the caesarean condition of the participant		
	Caesarean section cause	CS. CAUSE
	Case type	CASE TYPE
	Fasting period	FASTING PERIOD
	Previous type of anesthesia	PTA
	Current anesthesia type	CAT
	Time of surgery	TIME SURGERY
Participant's health evaluation parameters		
	Comorbid disease history	
	Disease	
	Drug history	
	Drug	
	Laboratory values are suitable for spinal anesthesia	LSSA
	Anesthetist choice spinal anesthesia	ACSA
	Previous surgery	PREVIOUS SURGERY
	Asa	ASA
	Mallampati	MALLAMPATI
Anesthesia preference-related parameters		
	Patient's preference for general anesthesia	PPGA
	Patient's preference for spinal anesthesia	PPSA
	The patient's fear of general anesthesia	PFGA
	The patient's fear of spinal anesthesia	PFSA

Analyzes in the study were carried out using R software. With the Information Gain and Chi-Square methods, which are among the filtering methods, the number of 24 usable parameters has been reduced to 16. For the classification method applied to the data sets, 80% of the data was used as training data and 20% as test data with the hold out method.

Data analysis in the research was completed in 2 parts. The first part applied classification and clustering methods to the raw data containing all parameters. In the second part, Chi-square and Information Acquisition were used as parameter selection methods, classification, and clustering analyzes were performed on the reduced data set, and the results were compared.

RESULTS

In this part of the study, data mining results is presented. Although analysis conducted on all data including additional parameters such as education, BMI and normal birth number, only the findings representing the highest performance will be mentioned.

Classification Method Findings

It is observed that the same parameters are selected with the Information Acquisition and Chi-square methods used for parameter selection. Parameters selected in order of weight are ACSA, PPGA, PPSA, LSSA, PFGA, PFSA, CS. CAUSE, CASE TYPE, TIME SURGERY, FASTING PERIOD, PTA, PREVİOS SURGERY, CS. NUMBER, MALLAMPATI, WEIGHT.

Table 3 demonstrates that the performance value of the decision trees obtained through Gini algorithm based on the accuracy criterion is equal in both datasets. In addition, the decision tree obtained through the Gini algorithm, the pruned decision tree obtained through the Gini algorithm and the performance tree based on the accuracy criteria of the decision tree obtained by the C5.0 algorithm were determined as 96.61%, 94.91% and 98.87% respectively.

Table 3. Model Performance Evaluation

	Gini Algorithm	Pruned Gini Algorithm	C5.0 Algorithm
Accuracy	0.9661	0.9491	0.9887

Results Related to Cluster Analysis

Figure 1 and **Figure 2** indicate the histograms that were created to provide information about the clustering analysis performed before and after the parameter selection. **Figure 1** reveals that all the patients in the 4th cluster have the characteristics that require general anesthesia. Moreover, the cluster analysis after parameter selection suggests that the patients in the second cluster have the similar characteristics. The cluster analysis performed before the selection suggests that all the patients in the 5th cluster and almost all of the patients in the 4th cluster have characteristics that are suitable for general anesthesia. In addition, in the post-selection clustering analysis, it is determined that all the patients in the first cluster have tendency to general anesthetics.

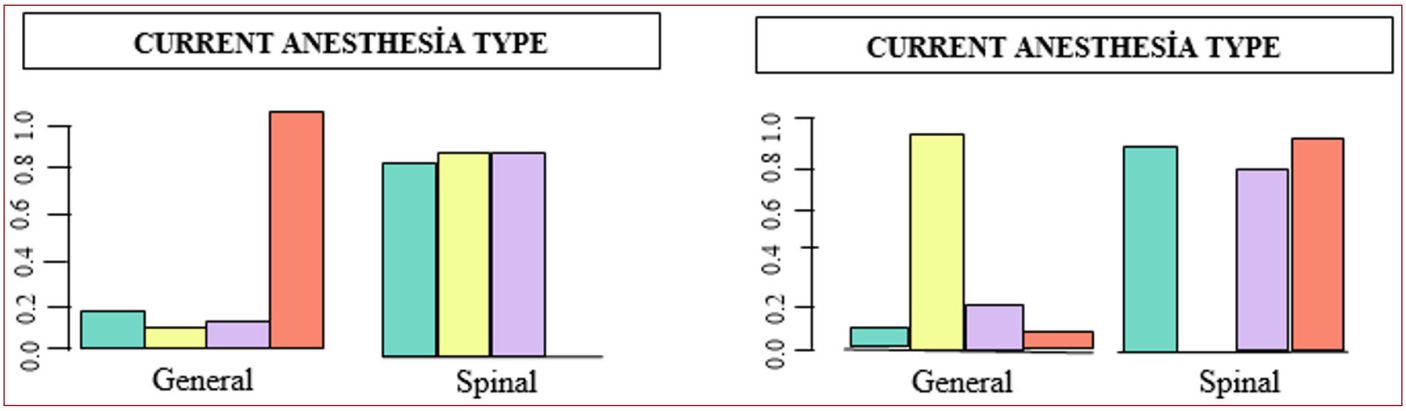

Figure 1. Pre-selection and post-selection clustering analysis for K=4

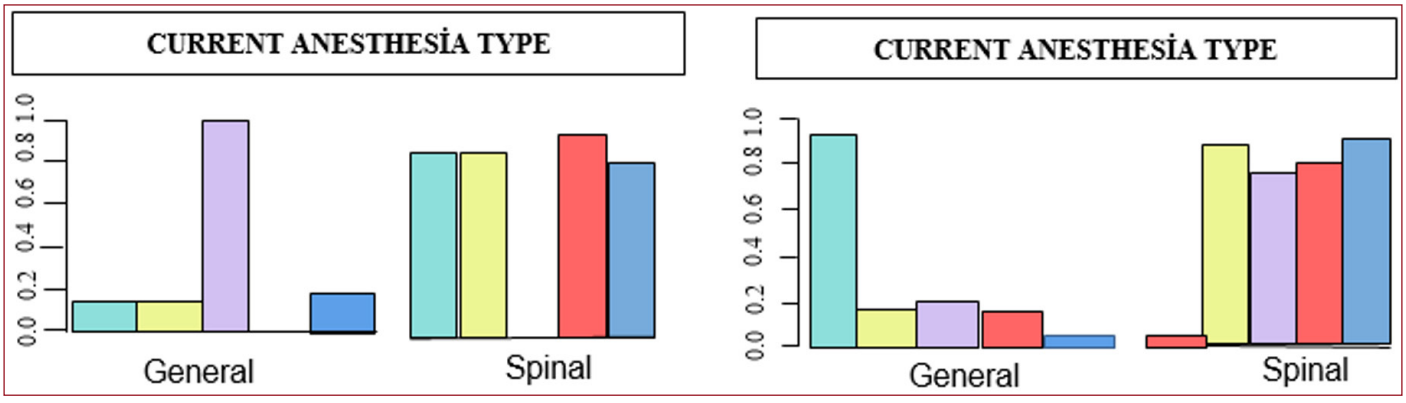

Figure 2. Pre-selection and post-selection clustering analysis for K=5

In addition, it was also concluded that case types of the patients were very urgent and the reasons for cesarean section were "3" (Fetal Distress) or "4" (Decollete Placenta) and the characteristics of mallampati class was 2. These findings were also in line with the clustering analysis conducted on the data that were obtained after parameter selection.

In addition to these characteristics, the clustering analysis conducted on the data that were obtained before parameter selection indicated that the majority of the patients in a cluster were between 20-40 years and their height varied from1.55 to 1.70. It was also observed that these patients were in the 35-40 weeks of gestation, had no concomitant diseases, no history of any drugs and their ASA classes were 2.

DISCUSSION

The purpose of this study is to extract the pattern from the previous data consisting of anesthesia decisions made by anesthetists for cesarean section and to investigate unpredictable or unusual relationships with the help of data mining methods. For this purpose, data were collected from 300 participants who gave birth by cesarean section in a maternity hospital. The ACSA attribute had the most significant importance in both methods. This also provides an evidence of how important it is for the patient to act with the advice of a physician in terms of having a healthy birth.

In cluster analysis, it was discovered that a pattern was formed in the selection of the data set into clusters 4 and 5 before and after parameter selection.

As a result of both clusters, it was found that the majority of the patients in one cluster were in the range of 55-80 kg and their fasting duration ranged between 5-12 hours and they were taken to the operation between 00:00-06: 00 a.m. In addition, it was argued that the majority of these patients had no previous surgery and received no anesthesia.

In this study, Gini and C5.0 algorithms were applied on the data sets as classification methods. According to the results, C5.0 algorithm had the highest performance. Decision trees were discussed with the anesthesiologists. They stated that although age parameter is effective in determining the type of anesthesia as a result of classification analysis, it is not effective in decision making. This may be due to the fact that age is already included in the biochemistry tests.

There is no previous data mining study on the type of anesthesia. However, the analysis of the data mining studies in the medical literature indicated that the study obtained similar values to the success performance of the decision trees created in the studies of Topaloğlu et al.[9] Abdar et al.[7] and Şatır et al.[10] Therefore, it seems that the decision trees mentioned above can be used by anesthesiologists or medical informatics specialists.

CONCLUSION

The study demonstrates that the C5.0 algorithm outperforms other algorithms in accurately predicting the type of anesthesia, achieving an accuracy rate of 98.87%.In addition, a notable result of the study is that the cluster analysis was found to be effective on the age of the patients, operation time, previous anesthesia type, number of previous cesarean sections, fear of anesthesia and previous surgical operations on the type of anesthesia in cesarean section cases.

In the light of the aforementioned results, it is recommended to use patient data to inform the patients before operation. Because it is notable that the field experts still have insufficient level of understanding many patterns obtained by data mining methods. In addition, infographics, brochures are necessary or events such as meetings are supposed to be organized in order to increase the awareness of patients. Future research could explore alternative data mining methods, such as deep learning approaches or ensemble models, to assess the generalizability of the findings. Furthermore, repeating the analysis with a larger dataset would enable comparison of the results.

On the other hand, the study has some limitations such as the sample size, the fact that it was carried out with a limited number of algorithms, and the data was collected in a limited time period of three months..

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Atatürk University Medical Faculty Ethics Committee (Date: 15/02/2018, Decision No: 2018/46).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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