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Research article

Defining difficult laryngoscopy findings by using multiple parameters: A machine learning approach

Moustafa Abdelaziz Moustafa [a,*], Shahira El-Metainy [a], Khaled Mahar [b], Essam Mahmoud Abdel-magied [c]

[a] Alexandria Faculty of Medicine, Alexandria, Egypt
[b] Arab Academy for Science and Technology, Alexandria, Egypt
[c] Faculty of Commerce, Alexandria, Egypt

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ABSTRACT

Background: Preoperative identification of patients whose trachea will be difficult to intubate would decrease the rate of anesthesia related adverse respiratory events. Each test for airway examination may predict a separate aspect of airway. A computer-based approach is tested in this study to precisely evaluate difficult laryngoscopy.

Aim of the work: Aim of the work was to evaluate the efficacy and accuracy of a multiparameter computer-based system for prediction of difficult laryngoscopy.

Study design: 50 Adult patients presenting for non emergency surgery at Alexandria main university hospital from February 2015 to Feruary 2016 with unanticipated difficult laryngoscopy were assessed post-operatively according to selected nine airway parameters. The same was done for their matched 50 controls after full recovery from general anesthesia. All data were entered into an information–based computer system where they were converted into numerical variables.

All data have been processed and analyzed using the Microsoft visual studio 2008 (C#.net) and WEKA (Waikato Environment for Knowledge Analysis) machine learning algorithms. Classification was done using J48 algorithm based on a decision tree and a "Weighter" filter was used to allow one to specify a numeric attribute to be used as an instance weight.

Results: Processed data have been designed as a software termed **"Alex Difficult Laryngoscopy Software" (ADLS)**. Positive predictive value was 76%, Negative predictive value was 76%, Matthews correlation coefficient was 0.52 and area under the ROC curve was 0.79.

Conclusion: **"Alex Difficult Laryngoscopy Software" (ADLS)** is a machine learning program for prediction of difficult laryngoscopy. New cases can be entered to the training set thus improving the accuracy of the software.

1. Background

Safe airway management is crucial in anesthesiology and resuscitation. Clearly, preoperative prediction of patients in whom laryngoscopy is difficult would decrease the rate of anesthesia related adverse respiratory events [1]. This requires a precise preoperative airway assessment. But still there is a controversy which tests and anatomical landmarks are the best predictors [2]. Difficult laryngoscopy is described in 1.5–3% of patients [3].

The ability to predict difficult laryngoscopy permits anesthesiologists to take precautions to decrease the risk [4]. Each test for airway examination may predict a separate aspect of the airway so, it is crucial to examine multiple parameters for proper airway assessment. In the present research, nine different parameters were taken into consideration in a computer-based approach to evaluate difficult laryngoscopy.

Data mining algorithms have many implementations. WEKA is one of such implementations and it is an open source software developed at the University of Waikato in New Zealand [5]. Prediction is one of those implementations that can be used based on training the program on input and output data [6]. This criterion has been used in the present study to allow the program predict difficult laryngoscopy according to input of cases and their parameters measurements.

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* Corresponding author.
E-mail address: m.3abdelaziz@hotmail.com (M.A. Moustafa).

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2. Aim of the work

Aim of the work was to evaluate the efficacy and accuracy of a multiparameter computer-based system to define difficult laryngoscopy.

3. Ethical approval

The study was approved by the local ethical committee of Alexandria Faculty of Medicine. A written informed consent was obtained from all participants.

4. Patients selection

Adult patients presenting for non emergency surgery at Alexandria main university hospital from February 2015 to February 2016 with unanticipated difficult laryngoscopy excluding major external facial or neck abnormalities, laryngeal abnormalities or tumors. Patients' age was ranging from 18 to 60 years. Unanticipated difficult laryngoscopy was identified by an experienced anesthesiologist (at least 5 years of experience) and defined as a view of the larynx grades 2B-4 according to Cook's modification [7] of Cormack-Lehane's classification [8].

5. Study design

Postoperatively, adult patients who had unanticipated difficult laryngoscopy over the study period were 50 and were closely matched demographically according to age and gender to 50 control patients chosen such that no difficulties were encountered during laryngoscopy or tracheal intubation.

Airway assessment was done postoperatively for the difficult laryngoscopy patients and their matched controls after full recovery from general anesthesia by a single blinded anesthesia consultant and focused on airway assessment which included the following parameters:

(1) Body mass index (BMI) = Weight in kilograms/Height in meters^2: Grade 0 = < 18.5
Grade 1 = 18.5–24.9
Grade 2 = 25–29.9
Grade 3 = 30 or greater
(2) Neck circumference: measured using a flexible tape at the level of the cricoid cartilage while patients were in the sitting position with the head and neck in the neutral posture. Grade 0 = <44 cm and Grade 1 = >44 cm
(3) Mandibular length. Grade 1 > 9 cm and Grade 2 < 9 cm
(4) Interincisor distance [9]: the patient is asked to open his/her mouth as wide as possible and the distance between upper and lower incisors was measured by a small ruler in the midline. Grade 1 = >4 cm and Grade 2 = <4 cm
(5) Thyromental distance [5]: measured by a small pocket ruler with the head fully extended and the mouth closed. Grade 1 = >6.5 cm and Grade 2 = <6.5 cm
(6) Sternomental distance [5]: measured by a ruler with the head fully extended and the mouth closed. Grade 1 = >13.5 cm and Grade 2 = <13.5 cm
(7) Modified Mallampati score [10]: It was performed with the patient in the sitting position and the neck held in neutral position and the tongue fully protruded without phonation.
Grade 0: Tip of the epiglottis is seen.
Grade 1: Tonsils, pillars and soft palate are clearly visible.
Grade 2: The uvula, pillars and upper pole are visible.
Grade 3: Only part of the soft palate is visible.
Grade 4: Only the hard palate is visible.
(8) Upper lip bite test (ULBT) [11]: The ULBT class was determined according to the following criteria:
Grade 1: Lower incisures can bite the upper lip above the vermilion line.
Grade 2: Lower incisors can bite the upper lip below the vermilion line.
Grade 3: Lower incisors cannot bite the upper lip
(9) Atlanto-occipital joint extension [12]: The patient was asked to hold head erect, facing directly to the front, then was asked to extend the head maximally and the examiner estimates the angle traversed by the occlusion surface of upper teeth. Any reduction in extension was expressed in grades: Grade I: $\geq 35°$, Grade II: 22–34°, Grade III: 12–21° and Grade IV: $\leq 11°$.

All data were entered into an information–based computer system where they were converted into numerical variables. Scores were classified into different categories that were supposed to be correlated with the difficulty of the laryngoscopic view.

6. Data analysis

The analysis aim is to classify data into two classes: Easy, which combines classes1 and 2A and Difficult, which combines classes 2B, 3A, 3B and 4. Each record was assessed using nine airway parameters that have been used for classification. For this purpose, data mining or machine learning algorithms were applied. Data mining is an interdisciplinary field which involves databases, statistics, and machine learning for finding patterns and consistency in sets of data [5].

The present study classifies data by using J48 Decision tree algorithm and illustrates it as follows. During the training phase of the program, it selects the parameter which correlates highly with the occurrence of difficult laryngoscopy. All patients who have difficult laryngoscopy are categorized in this area. While, other patients who are not difficult are put in another node of the tree and another parameter is started to be taken into consideration which is having a less correlation with difficult laryngoscopy and so on to complete the whole parameters tree.

Once the decision tree is complete, the order of attribute selection obtained by the tree is followed in each new case and hence prediction can be done according to the data base in the program which is designed in the form of a decision tree.

6.1. Proposed solution

All data have been processed and analyzed using the following two software programs:

- Microsoft visual studio 2008 (C#.net) [13]

IF-THEN-ELSE rules

- WEKA (Waikato Environment for Knowledge Analysis) machine learning algorithms [14].

In the present study, a system was proposed that performs processing and analysis of data through the following steps:

Step1: Extracting Patient classification

Through airway parameters grades window (Fig. 1), and using IF-THEN-ELSE rules, the system in this step automatically determines whether laryngoscopy is expected to be difficult or easy. This is done after insertion of the parameters values for each patient, then

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