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Original Research Article

Tracheostomy as an Independent Risk Factor of ICU Readmission

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ABSTRACT

Readmission to Intensive Care Unit (ICU) is associated with poor patients' outcomes. Prediction of risk of ICU readmission may help improve discharge decision making. Tracheostomies are increasing in ICU because of the safety of the procedure, and its benefits in patients' management. However, studies are scarce on the evaluation of tracheostomy as an independent risk factor of ICU readmission.

Objective: To investigate whether discharge from ICU with tracheostomy is an independent risk factor of ICU readmission.

Design: Retrospective single-center observational study, on patients discharged from ICU of King Saud Medical City (KSA – Riyadh) to identify differences between readmitted and non-readmitted patients, and recognize independent risks of readmission through logistic regression.

Results: Readmitted patients had higher average age and average APACHE 4 score, longer average length of stay, lower GCS on discharge, more tracheostomized patients, and were more frequently medical cases. A well fitted multivariate logistic regression model identified Age (OR 1.011, 95% CI: 1.001 – 1.021), LOS (OR 1.013, 95% CI: 1.004 – 1.021), APACHE 4 score (OR 1.01, 95% CI: 1.003 – 1.017), GCS (OR 0.86, 95% CI: 0.78 – 0.95), and tracheostomy (OR 2.7, 95% CI: 1.4 - 5) as risk factors of ICU readmission. The predictive model of readmission had AUC of 0.82(95% CI: 0.78 – 0.86). A predictive nomogram of the probability of readmission was constructed to be used for individual patients using these five factors.

Conclusion: There is evidence that discharge from the ICU with tracheostomy is an independent risk of ICU readmission.

Key words: critical care, intensive care, risk factor, readmission, tracheostomy

INTRODUCTION

Readmission to the Intensive Care Unit (ICU) has been associated with worse patients' outcomes, such as higher mortality [1] up to 2 to 11 times that of non-readmitted patients and two to three times longer length of stay (LOS). [2] Furthermore, unplanned ICU readmission places a financial burden on healthcare systems. [3]

As the decision to discharge a patient from the ICU is entirely a subjective judgment of the attending intensivist, it may be influenced by factors such as the high demand for ICU beds, and the critical condition of patients waiting to be admitted to ICU. [4,5] Therefore, several attempts have been made to identify risk factors associated with ICU readmissions, and different models of prediction have been put forward [6-11] to aid improve discharge decision making by attending intensivists.

Unfortunately, very few of these prediction models have been well validated [12,13] if at all, and with conflicting results. [14,15]

In the ICU setting patients undergoing tracheostomy are increasing, [16]

particularly in view of the safety of performing the procedure at the bedside, [17] and the benefits tracheostomy provides for the management of patients in the ICU, such as facilitation and maintenance of airway, as well as aiding in weaning from mechanical ventilation. [18] Despite this fact, studies investigating tracheostomy as risk factor of ICU readmission remain scarce. [4, 19]

Objectives:

- To compare readmitted and non-readmitted patients to the ICU with regards to certain demographic and clinical parameters.
- To investigate whether or not discharge from the ICU with tracheostomy is an independent risk factor of ICU readmission.
- To generate a prediction model of ICU readmission.

Study Design:

This was a retrospective observational single center study, performed in the ICU of King Saud Medical City (KSMC), Riyadh, Kingdom of Saudi Arabia. KSMC is a tertiary referral center, with 1200 beds, and a 127 beds ICU.

Between January 1, 2016 and December 31, 2016, a total of 2447 patients were admitted to our ICU and 2442 patients were discharged, out of the discharged patients we excluded:

- Deaths in ICU
- Discharged against medical advice (DAMA).
- Transfer to other hospitals or discharge home.
- All discharges from the Burn and Maternity ICU.
- Patients who were admitted for routine post-operative observation (Fast-Track).
- All patients less than 18 years of age.

These exclusions accounted for 1479 patients, remaining 963 patients were divided into two groups:

- Readmission group (R): Included patients who were readmitted to ICU at any time of their hospital stay, either physically or by reconnection to mechanical ventilation in the ward. However, patients who were readmitted for routine post-operative observation (fast track) were excluded. Readmission group had 157 patients.
- Non-Readmission group (NR): Included all patients who were discharged alive from the ICU, and subsequently discharged from the hospital either to home or to another hospital or healthcare facility such as rehabilitation centers. Excluded from this group were patients who died suddenly in the ward without ICU involvement. Non-Readmission group included 697 patients.

Figure 1 describes the groups of the study.

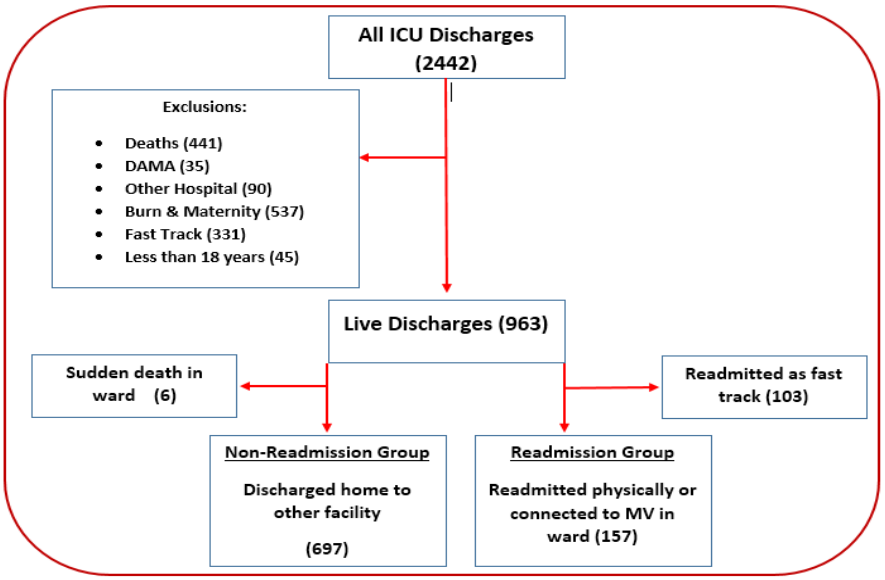

Figure 1: Study groups.

Data Collection:

For all the patients included in both groups, the following data were collected using the ICU database:

- Age (years).
- Gender
- ICU length of stay in days (of the first ICU admission).
- APACHE 4 score (of the first ICU admission).
- Glasgow Coma Scale (GCS) at time of discharge from ICU.
- Area from which the patient was initially admitted (Ward – ER).
- Type of condition of initial admission (Medical – Surgical).
- Whether or not the patient was tracheostomized at the time of discharge.

Statistical Method:

Continuous parameters were reported as mean (standard deviation), and compared between groups using student t test. Categorical parameters will be reported as Number (%), and compared between groups with chi square test.

Parameters with significant differences between groups will be entered in a multivariate logistic regression model with the binary dependent variable as readmission, using enter method with p value < 0.2, and results reported as Odds Ratio (95% CI). Goodness of fit of the model will be tested with Pearson chi square goodness of fit test for logistic regression. Using probabilities recorded by the logistic regression model, a ROC curve will be drawn for the prediction model.

Parameters identified by logistic regression to be independent predictors of ICU readmission will be used to generate a nomogram for prediction of ICU readmission probability.

All statistical tests are two-tailed, and considered significant if p value is less than 0.05.

SPSS® version 19 for windows (IBM SPSS Statistics for Windows, Version 19.0. Armonk, NY: IBM Corp.) was used to perform statistical tests, and Stata ® version 13 (StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP.) was used to generate the probability of readmission prediction nomogram.

RESULTS

Results of the predefined demographic and clinical parameters are summarized in table 1, and they were as follows:

Table 1: Demographic and clinical parameters of the study groups.

	Readmission Group (N=157)	Non-Readmission Group (N=697)	p value
Age mean(SD)	55.5 (18.3)	43.9 (28.4)	< 0.001
Gender: Male N(%)	125 (79.6%)	544 (78%)	= 0.75
ICU LOS mean(SD)	40.4 (40.3)	14.2 (20.2)	< 0.001
APACHE 4 score mean (SD)	86.7 (28.7)	70.7 (30.8)	< 0.001
GCS mean (SD)	11.2 (3)	13.8 (2)	< 0.001
Admission Area: ER N(%)	116 (74%)	530 (76%)	= 0.57
Condition: Surgical N(%)	60 (38.2%)	346 (49.6%)	= 0.01
Tracheostomy: Yes N(%)	85 (54.1%)	75 (10.8%)	< 0.001

ICU: Intensive Care Unit, LOS: Length of stay, APACHE: Acute Physiology and Chronic Health Evaluation, GCS: Glasgow Coma Scale, ER: Emergency Room.

Readmission group (R) included 157 patients, while Non-Readmission group (NR) included 697 patients, average age of R group was 55.5 (18.3) while that of group NR was 43.9 (28.4) (p < 0.001). Readmission group included 125 males (79.6%) and Non-Readmission group included 544 males (78%) (p = 0.75). The average ICU LOS of the first admission in Group R was 40.4 (40.3) and that of NR group was 14.2 (20.2) (p < 0.001), as for the APACHE 4 score of the initial admission R

group had an average of 86.7 (28.7) while NR group had an average of 70.7 (30.8) ($p < 0.001$), the average GCS of R and NR groups was 11.2 (3) and 13.8 (2) respectively ($p<0.001$), 116 patients (74%) in the readmission group were initially admitted from the ER, while 530 patients (76%) in the non-readmission group were admitted from the ER initially ($p=0.57$), in group R 60 patients were surgical cases (38.2%), whereas surgical cases in the non-readmission group were 346 (49.6%) ($p = 0.01$), of the readmission group 85 patients were tracheostomized at the time of discharge (54.1%), while 75 patients from the non-readmission group (10.8%) were tracheostomized at the time of ICU discharge ($p< 0.001$).

Parameters with significant statistical difference between the two groups (Age, LOS, APACHE 4, GCS, condition type, and tracheostomy) were fitted in a multivariate logistic regression model, our model showed goodness of fit when tested with chi square goodness of fit test for logistic regression ($p < 0.001$).

Results of logistic regression (table 2) showed that five parameters were associated with increased risk of readmission, namely: age (OR 1.011, 95% CI: 1.001 – 1.021), LOS (OR 1.013, 95% CI: 1.004 – 1.021), APACHE 4 score (OR 1.01, 95% CI: 1.003 – 1.017), GCS (OR 0.86, 95% CI: 0.78 – 0.95), and discharge with tracheostomy (OR 0 2.7, 95% CI: 1.4 - 5), while the type of condition was not found to be significant in the model (OR 0.8, 95% CI: 0.6 – 1.28)

Table 2: Results of Logistic Regression:

Parameter	OR	95% CI	P value
Age	1.011	1.001 – 1.021	0.03
LOS	1.013	1.004 – 1.021	0.004
APACHE 4	1.01	1.003 – 1.017	0.003
GCS	0.86	0.78 – 0.95	0.003
Tracheostomy	2.7	1.4 - 5	0.002
Surgical Case	0.8	0.6 – 1.28	0.43

The recorded probabilities of readmission that resulted from the logistic regression model were used to plot a ROC curve (fig. 2) that had an area under the curve of 0.82 (95% CI: 0.78 – 0.86)

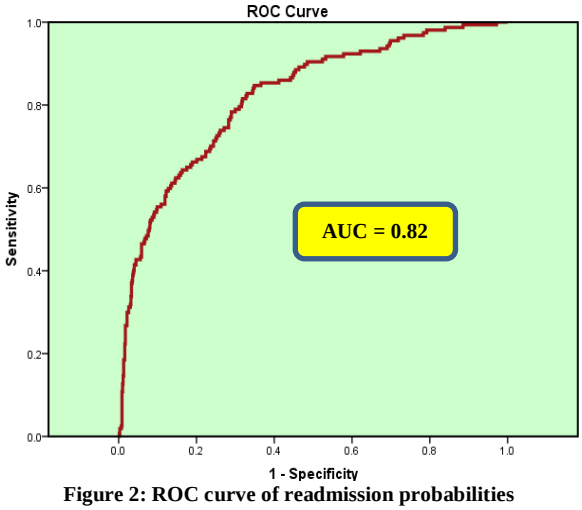

Figure 2: ROC curve of readmission probabilities

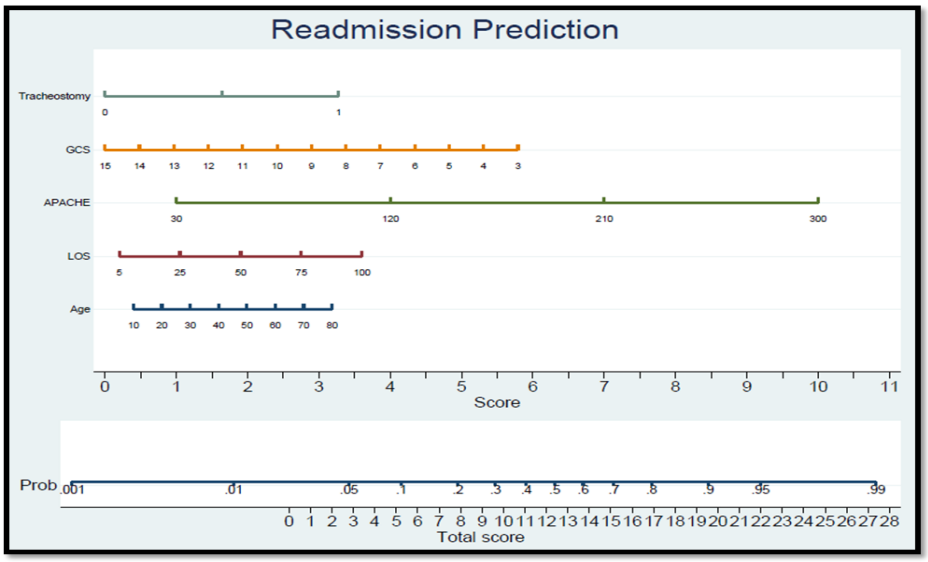

Figure 3: Probability of readmission prediction nomogram

The parameters that were identified by logistic regression model as independent predictors of ICU readmission were used to construct a nomogram (figure 3) of ICU readmission probability prediction.

DISCUSSION

In our study there was a statistically significant difference between the Readmission and non-readmission groups in some parameters, age, ICU LOS, and APACHE 4 score of admission were significantly higher in the readmission group, and the readmission group had more medical cases, lower GCS at discharge, and more tracheostomies, whereas gender and source of initial admission did not differ between the groups. The logistic regression model of factors with significant differences between the groups was well fitted, and it resulted in identifying five independent risk factors of ICU readmission including tracheostomy, in addition toage, GCS at discharge, APACHE 4 score on admission, and ICU LOS. When the recorded probabilities of readmission generated from the model were used to plot a ROC curve of readmission probability, it had a very good predictive capability, with area under the curve > 0.8. Our results were consistent with some results obtained by other researchers, and differed with others. Several studies on ICU readmission reported significantly higher age in the readmission group. [7,15,20,21] The ICU LOS of the initial admission was similarly reported higher for the readmission group than the non-readmission group in studies validating a readmission to ICU risk score, [21,22] most of the studies addressing ICU readmission evaluated severity of patients using APACHE 2 score, and did not report difference between the two groups. [4,19,20,22] Several authors reported lower GCS in the readmission group [15,20,23] inversely, others reported higher (better) GCS in the readmission group [4] or found no difference. [22] A similar finding of predominance of medical cases in the readmission group was reported by Markis et al, [23] as for the prevalence of tracheostomy in the readmission group, Rosa et al [21] reported a statistically higher percentage of tracheostomies in the readmission group, while other authors [4,19,22] did not. The contradictory results of our study and previous research may be because of the fewer number of patients in the readmission group in most of those studies compared to ours, only Kastrup et al [15] and Markis et al. [23] had more patients than our study in the readmission group. Furthermore, such conflicting results of studies on outcome of tracheostomy patients are common, and led one author [19] to conclude that it is difficult to predict outcomes of individuals undergoing tracheostomy in the ICU setting. Study design also has its impact on the results, studies which are case-control [21] are not expected have differences in the study groups.

Few studies conducted a logistic regression model to predict ICU readmission of tracheostomized patients, some of the independent risks of ICU readmission identified in our study were also reported by other studies, such as age and ICU LOS, [21] GCS at discharge and ICU LOS were independent risk factors in the model by Gajic et al. [22] In one study [21] the need for tracheostomy was identified as a risk factor for ICU readmission, but only in a univariate logistic regression with OR of 2.96, but was eliminated in the multivariate model, however, it is important to mention that the binary outcome of that model was not only readmission, but also death.

CONCLUSION

Our study provides evidence that tracheostomy is an independent risk factor for ICU readmission, along with age, APACHE 4 score of admission, ICU LOS, and GCS at discharge. These five factors can be used to predict probability of ICU readmission with very good predictive ability.

This prediction model needs to be validated in a larger prospective study.

Study Limitation:

Our study has a limitation of design being a retrospective observational study. The data collected for each patient were limited by availability, further evaluation of the five predictive factors is required among a larger set of patient's clinical and demographic data. The number of patients included in our study was also a limitation due to the time period of the study, similar or better design studies are required with a larger sample size.

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