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Cost Analysis of Open Surgical Bedside Tracheostomy in Intensive Care Unit Patients

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Abstract

Objectives: Open surgical tracheostomy (OST) is a common procedure performed on intensive care unit (ICU) patients. The procedure can be performed bedside in the ICU (bedside open surgical tracheostomy, BeOST) or in the operating room (operating room open surgical tracheostomy, OROST), with comparable safety and long-term complication rates. We aimed to perform a cost analysis and evaluate the use of human resources and the total time used for both BeOSTs and OROSTs. **Methods:** All OSTs performed in 2017 at 5 different ICUs at Oslo University Hospital Ullevål were retrospectively evaluated. The salaries of the personnel involved in the 2 procedures were obtained from the hospital's finance department. The time taken and the number of procedures performed were extracted from annual reports and from the electronic patient record system, and the annual expenditures were calculated. **Results:** Altogether, 142 OSTs were performed, of which 122 (86%) and 20 (14%) were BeOSTs and OROSTs, respectively. A BeOST cost 343 EUR (95% CI: 241.4-444.6) less than an OROST. Bedside open surgical tracheostomies resulted in an annual cost efficiency of 41.818 EUR. In addition, BeOSTs freed 279 hours of operating room occupancy during the study year. Choosing BeOST instead of OROST made 1 nurse, 2 surgical nurses, and 1 anesthetic nurse redundant. **Conclusion:** Bedside open surgical tracheostomy appears to be cost-, time-, and resource-effective than OROST. In the absence of contraindications, BeOSTs should be performed in ICU patients whenever possible.

Keywords

tracheostomy, intensive care units, costs and cost analysis, health expenditures, critical care

Introduction

Tracheostomy is a commonly performed procedure in intensive care unit (ICU) patients who require prolonged mechanical ventilation. Converting from endotracheal intubation to a tracheostomy has several benefits for the ICU patient, such as better long-term laryngeal function, improved safety, more patient comfort requiring less sedation and pain medication, improved and easier weaning from the mechanical ventilator, and the possibility of speech therapy, initiating oral intake of medication, and feeding, which all might contribute to shorter ICU and hospital stay.[1-3] The evidence is unclear whether or not tracheostomy reduces the risk of ventilator-associated pneumonia.[3,4] There are 2 types of tracheostomies: open surgical tracheostomy (OST), which can be performed bedside (BeOST) or in the operating room (OROST), and percutaneous dilatational tracheostomy (PDT).

Percutaneous dilatational tracheostomy was popularized after 1985 and has become an increasingly used alternative to the traditional OST.[5] Typically performed bedside in the ICU,

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PDT omits the need to transfer unstable patients to the operating room (OR). This makes it an efficient procedure, in terms of the number of personnel and equipment required, rendering it cost- and time-effective.[1,6] However, PDT is not recommended in patients with unfavorable neck anatomy or anomalies, coagulopathies, in emergency tracheostomies, or in patients with previous tracheostomies.[7] In addition, the evidence is ambiguous whether it is more cost-effective as compared to BeOST.[8] Thus, although PDT is the preferred option, some selected ICU patients still require traditional OST.

Bedside open surgical tracheostomy, OROST, and bedside PDT have comparable safety and long-term complication rates.[9,10] Although several studies have found that BeOST and OROST are equally safe,[11-15] OROSTs require in-hospital transport from the ICU to the OR, which might lead to adverse events and complications in critically ill patients. Thus, this renders BeOST a well-documented alternative to PDT when the latter is contraindicated. In addition, only a few studies have compared the economic and logistical aspects between BeOSTs and OROSTs.[16-18] In these studies, the cost analyses were based on hospital billing charges, which may be less generalizable than analyses based on participant salaries.[16-18]

Thus, the primary aim of the present study was to perform a cost analysis, derived from participant salaries, of BeOSTs versus OROSTs among critically ill ICU patients. As secondary aims, we explored both the time expenditure and use of human resources between the 2 procedures.

Patients and Methods

Oslo University Hospital Ullevål (OUHU) is a local hospital serving 480 000 people. It is also a regional trauma center for 3 million people. Oslo University Hospital Ullevål has approximately 1200 beds, and normally operates with approximately 35 adult ICU beds and 5 pediatric ICU beds in 7 different ICUs. In these ICUs, surgeons from the Maxillofacial Surgery Department perform BeOSTs. In this retrospective study, we registered all BeOSTs and OROSTs performed at OUHU from January 1, 2017, to December 31, 2017. The study was conducted on anonymized data and was approved by the Data Protection Officer at OUHU (no. 21/00696). It was considered exempt from patient consent requirements.

Procedures

Surgical preparation for OROST includes all events in the OR other than knife time, for example, transfer to and from the operating table, all anesthesia preparations including initiation and discontinuation of anesthesia, applying drapes, cleaning and shaving the patient, and rigging surgical instruments and equipment. OR nurses assist the surgeons throughout the procedure. In addition, an anesthesiologist, an anesthetic nurse, and cleaning personnel are present and involved in all OROSTs. The anesthetic nurse is continuously present to assist the anesthesiologist in the replacement and the removal of the endotracheal tube during surgery in addition to administration of drugs, handling of hemodynamics and ventilation issues.

For BeOSTs, surgeons perform all surgical preparation, including covering the patient with drapes, applying antiseptic solution to the skin, and unpacking surgical equipment. No OR nurses are present during BeOSTs. A mobile cart with all of the necessary surgical equipment is used. This is available at all times and is brought to the ICU before the BeOST is performed. The intensivist responsible as well as 1 ICU nurse are present during BeOSTs.

The surgical technique used for both BeOSTs and OROSTs is a standard OST technique. This consists of a horizontal skin incision, followed by dissection through the subcutaneous tissues. The strap muscles are then divided at the midline, and the thyroid gland is preferably luxated cranially or sectioned if needed, and the trachea is exposed. Two stay sutures are placed, and the trachea is incised vertically, followed by the insertion of a tracheostomy tube. Finally, the skin incision is then closed with sutures and the tracheostomy tube is secured with sutures and a neckband. The anesthesiologist/intensivist is continuously responsible for airway management and for the manipulation and removal of the present oral endotracheal tube in close collaboration with the surgeon.

Data Collection

Data were obtained from the ICUs' annual reports, where all procedures are prospectively registered. The number of OROSTs was collected from the electronic patient record system (DIPS version 7.3.16.11), in addition to data on procedure duration (knife time) and total OR time. Total OR time included all events in the OR other than knife time, for example, preparations, administration of anesthesia, and equipment assembly. As we lacked data on knife time for BeOSTs, we assumed it was equal to that of OROSTs (the same technical procedure performed by the same surgeons under similar anesthetic conditions). The time used for BeOST preparation as well as transport to and from the OR in conjunction with OROST was estimated based on the authors' experience.

Equipment costs were obtained from the OR service. The wages of the BeOST and OROST participants were extracted retrospectively from the hospital's salary system. These were obtained from January 1, 2017, to December 31, 2017. The total salary costs of those directly involved were divided by the number of full-time equivalents of the department. This yielded the mean cost per participant, which also included employment tax and social costs, that is, insurance and pension costs. The cost per minute per participant was calculated by dividing the mean cost by the standard working hours of the given profession. The currency used was Euro (EUR), which was converted from Norwegian kroner with a conversion rate of 0.1016 as of December 31, 2017. The cost per minute per participant was multiplied by the time the given participant was present during the procedure. Finally, the total costs of all participants were summarized. The calculations were based on the following participants:

OROST: Two nurses transporting the patient to and from the ICU, 2 surgeons, 1 anesthesiologist, 1 nurse anesthetist, and 2 surgical nurses.

BeOST: Two surgeons, 1 anesthesiologist, and 1 ICU nurse.

Statistical Analyses

The duration of the procedures in the OR is presented as the means and standard deviations (SDs). All statistical analyses were performed in IBM SPSS version 25 for Windows (IBM Corp). The time use of OROSTs which were performed as single surgery was used to perform the statistical analyses. To perform between-group analyses, the mean and SD of the procedural time expenditure of BeOST was extrapolated to be similar to that of OROST. The differences in time use were compared using an independent sample t test, and the results are given with 95% CIs. The cost effects were calculated as the difference in cost between the 2 procedures multiplied by the number of procedures performed in 2017. The SDs of the costs were estimated, and costs between the groups were compared using an independent sample t test. For calculating the amount of OR time made available (because the OSTs were performed bedside), the number of BeOSTs was multiplied by the total time expenditure of an OROST. We further calculated the number of extra operations that hypothetically could have been performed during the year by dividing the total time made available with the average time used for a maxillofacial surgical procedure from 2017. The latter was extracted from the hospital's surgical registry. All extractions from this registry were made by an employee at the OUH Finance department. A 2-tailed P value of <.05 was considered statistically significant.

Results

Altogether, maxillofacial surgeons performed 122 BeOSTs and 21 OROSTs in 2017. Seven OROSTs were performed as the only surgery (single OROST), whereas the other 14 were performed in combination with other surgical procedures. The single OROSTs were in 3 trauma patients, 2 medical patients, 1 orthopedic patient, and 1 oncology patient. The non-single OROSTs were in 5 patients with panfacial fractures, 2 in patients with fractures of the midface, 3 in patients with ballistic soft tissue and skeletal injuries, 2 in orthopedic trauma patients, and 2 in patients with head injuries. The time usage for one of the single OROSTs was missing, thus this was excluded from the analyses. The total time expenditure of an OROST, including transportation to and from the OR, was 82 minutes longer (95% CI, 65.2-98.1, $P < .001$) than a BeOST (ie, 2.5 times longer; Table 1). The accumulated time expenditure for all participants involved was 534 and 208 minutes for OROST and BeOST, respectively, a difference of 326 minutes.

The cost of the disposable surgical equipment used during a tracheostomy was 70.9 EUR (Table 2), independent of the location of the procedure.

The total cost of a BeOST was 343 EUR less than that of an OROST (Table 3), equalling a 55% reduction in costs. If the 122 BeOSTs performed in 2017 had been performed in the OR, this would mean 41.818 EUR lower cost efficiency. In addition, 1 nurse, the 2 OR nurses, and 1 anesthetic nurse would have been available for other tasks if BeOSTs had been performed (Figure 1).

Table 1. Time Use of OROST and BeOST, in Minutes.

	OROST	BeOST
Transport of patient	40	-
Knife time (SD)	40.7 (13.9)	40.7
Non-knife time (SD)	56,7 (25.8)	15
Total time used (SD)	137,4 (19.9)	55.7

Abbreviations: BeOST, bedside open surgical tracheostomy; OROST, operating room open surgical tracheostomy; SD, standard deviation.

Table 2. Costs of Surgical Items Used in OROST and BeOST.

	n	Cost (EUR)
Draping set	1	39.6
Surgical gloves	4	4.5
Local anesthesia	1	2.9
Portex tracheostomy cannula	1	19.3
Swivel connector	1	1.9
Tracheostomy neckband	1	2.3
Diathermy ground plate	1	0.4
Total		70.9

Abbreviations: BeOST, bedside open surgical tracheostomy; EUR; Euros; OROST, operating room open surgical tracheostomy.

In 2017, the total time used for maxillofacial surgeries in the OUHU OR was 1862 hours. Multiplying the total OR time expenditure of an OROST with the number of BeOSTs performed in the same year yielded a total time of 279 hours (35 eight-hour workdays), equalling 14.9% of the total OR time. With an average maxillofacial surgery operation spanning 2.8 hours, a hypothetical reduction of 279 hours of OR time means that 100 more patients could have undergone other relevant surgery during the year if the tracheostomies were performed outside the OR.

Discussion

In the present study, comparing the performance of BeOST and OROST in intubated ICU patients, we have shown that BeOST was 55% more cost efficient than OROST. In addition, if all tracheostomies in ICU patients had been performed bedside in the ICU, approximately 100 more patients per year could have undergone maxillofacial surgery due to more available OR time.

Comparable previous studies have revealed that both the total costs and cost difference between the 2 procedures vary greatly, which may be due to methodological differences as to how the costs were calculated or differences in hospital billing rates. Yoo and colleagues[16] found an almost 10-fold increase in the cost of OROST compared to BeOST, as did Wease et al.[19]

Table 3. Costs of Equipment and Participants Involved in OROST and BeOST.

	Cost per minute (EUR)	N; OROST	N; BeOST	Time; OROST (minutes)	Time; BeOST (minutes)	Cost; OROST (EUR)	Cost; BeOST (EUR)
Surgeons	1.43	2	2	41	56	116	159
Surgical nurse	1.04	2	-	97	-	202	
Anesthesiologist	1.52	1	1	81	41	123	62
Nurse anesthetist	1.01	1	-	97	-	98	
Nurse	0.99	2	1	40	56	79	55
Equipment cost	-	-	-	-	-	71	71
Total cost						689	347

Abbreviations: BeOST, bedside open surgical tracheostomy; EUR, Euros; OROST, operating room open surgical tracheostomy.

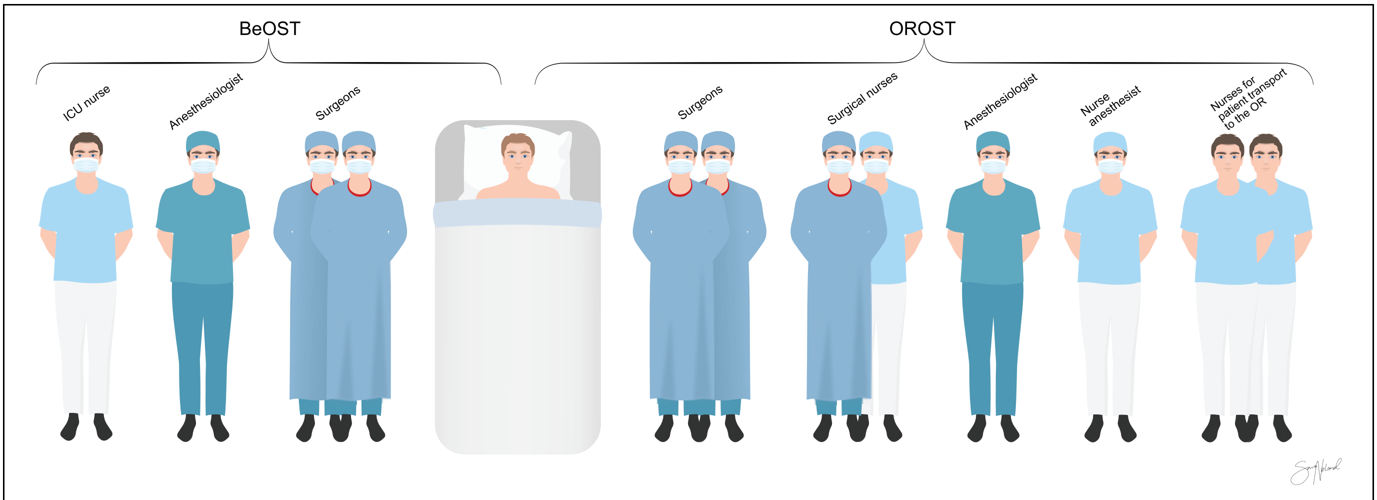

Figure 1. Participants involved in bedside open surgical tracheostomy (BeOST) and operating room open surgical tracheostomy (OROST).

Levin and coworkers, however, only found a 3.5% difference in favor of BeOST.[17] It is unclear, though, if the latter included time expenditure in the OR other than knife time. Lujan and colleagues included some additional time use in their calculations, but this was only because the OR cost was accrued by every 30 minutes recorded.[18] In a study on pediatric patients, Klotz and Hengerer found that BeOST was 86% cheaper than OROST, also including OR cleaning costs.[14]

Bedside open surgical tracheostomy is less demanding than OROST in terms of the numbers of personnel involved (4 vs 8). Our institution has a long tradition of performing BeOSTs on ICU patients, and the present study included more annual BeOSTs compared to other studies examining the cost-effectiveness of BeOST.[14,16-19] The large number of procedures performed at our institution relocates human resources and saves OR time for other patients. This is beneficial not only for the patients but also in light of the increasing demands on OR capacity, productivity, and efficiency in health care. By choosing BeOST in the ICU instead of OROST, surgeons do not have to depend on the availability of an OR, which would otherwise delay the procedure and potentially yield a worse patient outcome. This was shown by Yoo and colleagues, who found that patients who were selected for OROST waited significantly longer for surgery than patients who underwent BeOST. They also found that the latter had shorter ICU length of stay.[16]

Our study has several limitations. As this is a single center study, its generalizability is uncertain. All data were retrospectively collected. The exact time expenditure of a BeOST was not registered in the electronic patient system or in the annual reports of the different ICUs. Thus, the procedure length was estimated, which might be inaccurate. We believe, however, that this is unlikely because the 2 surgical procedures are technically exactly the same and are performed by the same team of surgeons. Further, it was not possible to obtain the exact time used to transport patients to and from the ICU to the OR. Accordingly, this was estimated based on our best knowledge. The same is true regarding the preparations for BeOST. As we lacked data on knife time for BeOSTs, we assumed it was equal to that of OROSTs (the same technical procedure performed by the same surgeons under similar anesthetic conditions). Furthermore, the study is limited by the small number of single surgery OROSTs that were performed during the study period.

We did not include the wages of the OR and ICU cleaning personnel. This could have underestimated the difference in costs between the 2 procedures, as cleaning is usually more extensive in the OR than in the ICU.

Although BeOST is more efficient than OROST in terms of the amount of health professionals needed, the former necessitates the presence of an intensivist and an ICU nurse which otherwise could have provided care for other ICU patients and procedures. This was not possible to quantify under the scope of the current study but is nevertheless a limitation as this could have indirectly underestimated the cost of BeOST. However, the patient responsible intensivist and nurse are the one being present, and other intensivists and nurses will be available for other patients during this procedure. Bedside open surgical tracheostomies are always performed daytime, and in the case of limited resources, the procedure might be delayed.

We did not examine complications, adverse events, or length of stay. This could have biased the cost analysis if one of the procedures had complications, which would have influenced costs that were not strictly related to the surgical procedure. A retrospective chart review would have given information about complication rates. This was, however, not feasible under the scope of the present study as it would necessitate a mandatory patient consent required from our Data Protection Officer. We nevertheless believe that the study's results, favoring BeOST versus OROST regarding costs, human resources, and time use, have value, despite the lack of reporting complications. Safety of BeOST versus OROST has previously been extensively examined without showing relevant differences.[11,16,17,19] The biggest study, from Futran et al in 1996, found no difference in early or late complications of 996 BeOSTs and 438 OROSTs.[11] In addition, it is not reasonable that the location of where the OST is performed should influence the rate of complications. Finally, all tracheostomies included in the present study were performed under the same conditions, with the same surgical preparations, equipment, and technique, making it less likely that any complications would differ between the 2 groups. Due to the institutional data protection officer's regulations, it was not possible to obtain why OROST was chosen instead of BeOST in the 21 OROST patients. In our opinion, however, this would not have changed the premise and findings of the study.

In conclusion, BeOST appears to be more efficient than OROST in terms of cost, human resources, and time used. It does not require an OR, which frees up time for other surgeries. We recommend that BeOST continue to be preferred over OROST for eligible patients.

Declaration of Conflicting Interests

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Supplemental Material

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