

COST MINIMIZATION ANALYSIS: USE OF DUAL AND TRIPLE LUMEN CENTRAL VENOUS CATHETER

Análise de custo minimização: uso do cateter venoso central de duplo e triplo lúmen

Análisis de costos minimización: uso del catéter venoso central de doble y triple lumen

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ABSTRACT

Objective: to analyze or use central venous catheter of double versus triple lumen in an intensive care unit.

Methods: study of custo-minimization, with quantitative approach to light of the economic avaluation of saúde. Foram analyzed custos e a ocorrência adverse events in amostra com 30 central venous catheter. A data queue is made through a checklist with data on the prognosis. The data are tabulated and analyzed from the decision tree through Tree Age® software. **Results:** central venous catheter triplo lúmen teve um custo related to adverse events of R\$ 7,648.22 apresentando-se superior ao duplo lúmen. **Conclusion:** a quantum of lumens is related to a higher incidence of adverse events and a higher custody. In this way, I contributed to nursing by directing the application of financial resources and orienting strategies to minimize the occurrence of adverse events.

Descriptors: Costs and cost analysis; Catheterization, Central venous; Intensive care units. Nursing care.

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RESUMO

Objetivo: analisar o custo da utilização do cateter venoso central de duplo versus triplo lúmen em uma unidade de terapia intensiva. **Métodos:** estudo de custo-minimização, com abordagem quantitativa à luz da avaliação econômica de saúde. Foram analisados custos e a ocorrência de eventos adversos em uma amostra com 30 cateter venoso central. A coleta de dados foi através de um check list com dados do prontuário. Os dados foram tabulados e analisados a partir da árvore de decisão através do software Tree Age[®]. **Resultados:** o cateter venoso central triplo lúmen teve um custo relacionado a eventos adversos de R\$ 7.648,22 apresentando-se superior ao duplo lúmen. **Conclusão:** a quantidade de lúmens está relacionada a maior ocorrência de eventos adversos e a um maior custo. Dessa forma, contribui com a enfermagem por direcionar a aplicação de recursos financeiros e orientar estratégias para minimizar a ocorrência de eventos adversos.

Descritores: Custos e análise de custo; Cateterismo venoso central; Unidades de terapia intensiva; Cuidados de enfermagem.

RESUMÉN

Objetivo: análisis de la utilización del catéter venoso central de duplex versus triplo lúmen in una unidade de terapia intensiva. **Métodos:** estudio de minimización, análisis cuantitativo de la luz económica de la economía. Otros analizados guardan y una situación de eventos adversos en la amostra com 30 cateter venoso central. Una coleta de dados para através de una lista de verificación con los datos del programa. Los datos de las tablas y los análisis a partir del momento de la decisión del software Tree Age[®]. **Resultados:** o cateter venoso central lúmen teve um custo relacionado a eventos adversos de R\$ 7.648,22 apresentando-se superior ao duplo lúmen. **Conclusión:** a quantidade de lúmens está relacionada con una mayor ocorrência de eventos adversos e um mayor custo. Dessa forma, contribui com a enfermagem por direcionar a la aplicación de recursos financieros y orientaciones estratégicas para minimizar la ocorrência de eventos adversos.

Descritores: Custos y análise de custo; Cateterismo venoso central; Unidades de terapia intensiva; Cuidados de enfermagem.

INTRODUCTION

The central venous catheter is indicated when peripheral access is impossible or according to the patient's indicated infusion therapy¹. Hospitalization of patients in intensive and semi-intensive care centers requires the use of advanced technologies for therapy and care, intravenous devices, especially the central venous catheter². With regard to the high incidence, caution with procedures involving vascular access should be a priority of the care team, so that effective surveillance provides prevention and control of adverse events.

The use of vascular access catheters has increased the safety of patients undergoing prolonged intravenous therapies and subsequent manipulations of the vascular network, including frequent control laboratory samples. However, there are adverse events related to the use of the double and triple lumen central venous catheter that generate significant costs in the hospital context.

Central venous catheters with higher lumens are estimated to be more likely to generate adverse events than those with lower lumens¹.

The Resolution establishing actions for patient safety in health services defines an adverse event as an incident that results in health risks. In the US, annual expenditures from adverse events have been estimated at \$17-\$29 billion annually. On average, 10.0% of hospitalized patients suffer some type of adverse event, of which 50.0% are preventable^{3,4}.

Most invasive devices used in intensive care are often handled by nursing. Thus, it is necessary for nurses to seek solutions that can contribute to reducing the occurrence of these adverse events, increasing safety and minimizing the negative impact on the patient, nursing staff and institution, as well as participating in the generation process of costs related to adverse events⁴.

Regarding adverse events related to the use of central venous catheters, a randomized study in patients with subclavian vein catheters for more than one week found a 2.6% incidence of bloodstream infection for those of the single lumen versus 13.1% in triple lumen catheters. In practice, it is estimated that each lumen increases manipulation by 15 to 20 times a day⁵⁻⁶.

The cost associated with bloodstream infection varies depending on the country, institution and unit in which the patient is located. Some US estimates point to an extra \$50,000 spending per episode of Primary Bloodstream Infection⁷.

According to the *Guidelines for the Prevention of Intravascular Catheter-Related Infections*, multiple lumens facilitate simultaneous administration of different infusions, but the risk of infection is higher in catheters with more lumens. The number of times the catheter is manipulated is a risk factor for the onset of infectious adverse events, but the number of solutions infused into the same lumen is a risk factor for drug incompatibility⁷⁻⁸.

In this sense, adverse events can be minimized by choosing the ideal central venous catheter in relation to its amount of lumens. For this, it is necessary to make available a greater variety of the catheter in question in the unit. This practice will allow proper decision making with the indication of infusion therapy.

In the evaluation of infusion therapy, the partnership of the medical team with the nursing team is crucial, since a multiprofessional process, in which one is responsible for prescribing the medicine and the other is responsible for frequently administering and manipulating the central venous catheter.

In this regard, the following question arises: Are there cost differences in the use of the double versus triple lumen catheter related to the occurrence of adverse events in intensive care unit patients? To answer this research, we have as objective to analyze the cost of using the double versus triple lumen central venous catheter in an intensive care unit.

METHODS

This is a descriptive, documental research with quantitative approach in the light of health economic assessment.

In the cost minimization analysis, the difference in equivalent health costs is calculated between alternative technologies that have been shown to produce equivalent health outcomes, differing only in the costs they incur. When two strategies have the same therapeutic efficacy and patient health consequences but different costs, the lowest cost strategy is preferable³.

The study site was in an adult intensive care unit of a public university hospital located in the city of Rio de Janeiro. The unit has 10 beds for critical care with varying profiles (clinical or surgical). The temporal clipping was from April to August/2017. Data collection occurred through medical records and nursing notes.

The evaluation of adverse events related to the central venous catheter was based on data obtained through a checklist prepared by the researchers. These data were collected daily at the end of each day shift. Were used: the document entitled "Book of qualities", which contained information on the place of insertion and removal of the catheter, with date, time and reason for removal (exteriorization, occlusion and infection); medical records, in which adverse events related to the central venous catheter are recorded, the treatment (blood culture - examination and used vials - and antibiotic therapy) and insertion of the central venous catheter in another vascular site; nursing records in the evolution after dressing change.

Standard operating procedures were used to calculate and account for expenditures on materials for insertion, removal and maintenance of the double and triple lumen central venous catheters, as they contain the materials to be used as standard.

The data on probabilities of occurrence of adverse events in the central venous catheters were taken from the literature and data collection in the institution studied. The cost data of the variables were used by the purchasing department of the institution.

As the inclusion registry was considered as using the double or triple lumen central venous catheter and the central venous catheter inserted in the hospital itself. How to specify the exclusion: double or triple lumen central venous catheter retired by the discharge and death sector care team.

Inclusion criteria were the use of the double or triple lumen central venous catheter and the central venous catheter inserted in the hospital. Exclusion criteria: double or triple lumen central venous catheter removed by the hospital care team in the situation of discharge and death.

The characterization variables of the insertion and maintenance procedures were described with relative frequencies, mean and standard deviation. The constructed analytical decision model compared the cost of using the

double lumen central venous catheter with the triple lumen related to adverse events in patients admitted to an intensive care unit. The data were used to support and elaborate the decision tree through the Tree Age® program, version 2015, tabulated and accounted in Excel®.

Decision trees are diagrams that allow you to represent and evaluate problems involving sequential decisions. To graph the decision tree, lines are usually used to identify the decision (for example, "yes" or "no") and knots to identify the issues to decide on. In the Tree Age® program two scenarios were built through the generated decision tree, contemplating the use of both catheters and their adverse events in the scenario. The adverse events studied were elected because they are the most evidenced in the literature and in practice, and are directly related to nursing care, namely: occlusion, exteriorization and infection.

All cost items in the procedure production process from the central venous catheter-related adverse event were identified and quantified, to which monetary value was attributed based on the methodological guidelines of economic assessment of health technology studies³.

The decision tree created by the software consists of two scenarios: double lumen central venous catheter and triple lumen central venous catheter. In both of them, two branches were created: one branch with the probability of adverse event occurring and the other with no adverse event. In the "adverse event" branch, three arms were generated in the tree: the probability of occlusion, of externalization and of infectious adverse events. In each of these probabilities of occurrences, the costs were calculated by multiplying the variables created. In the "occlusion" branch, the following variables were calculated: catheter removal cost, tray sterilization cost, field sterilization cost, dressing and catheter insertion cost, multiplied by the average cost of length of hospital stay. In "externalization", two possibilities were created: removal or non-removal of the catheter. In removal, the following variables were calculated: catheter removal cost, dressing and catheter insertion cost, multiplied by the average cost of length of hospital stay. When the catheter was not removed, the costs of the following variables were added: cost of insertion of the double lumen central catheter, multiplied by the average cost of length of hospital stay. In the "infectious adverse events", we calculated the variables: cost of insertion of the double lumen catheter, dressing cost and average cost of antibiotic therapy, multiplied by the average cost of length of hospital stay. "No adverse event" was calculated by multiplying the dressing cost variable by the average cost of the hospitalization days. In the triple lumen central venous catheter scenario the branch structure repeats, differentiating only the cost variable of the triple lumen central venous catheter insertion.

The study was approved by the Research Ethics Committee of the institution, respecting Resolution 466/12 of the National Health Council, justifying the absence of the Informed Consent Form, with the Certificate of Presentation

for Ethical Consideration 65560317.6.0000.5259 and opinion number 1,983,940, approved in March 27, 2017. The research was conducted according to the required ethical standards.

RESULTS

A total of 30 venous catheters were included in this study and 18 (60.0%) double lumen and 12 (40.0%) triple lumen catheters were analyzed. On the double lumen central venous catheter insertion site: 10 (56.0%) were inserted in the jugular, three (17.0%) in the subclavian and five (27.0%) in the femoral vein; and triple lumen insertion site: five (42.0%) inserted in the jugular vein and seven (58.0%) in the femoral vein. The average stay was 11 days for double lumen catheters and 8.09 days for triple lumen catheters. The average duration of stay of patients using the catheters studied was 9.03 days.

The prevalent medical diagnosis of eligible patients was pulmonary sepsis six (20.0%), followed by hepatic encephalopathy three (10%) and decompensated heart failure three (10.0%).

Regarding the occurrence of adverse events, the most frequent in double lumen catheter was the presence of infection eight (44.4%), followed by occlusion six (33.3%) and exteriorization four (22.2%). In the triple lumen catheter, the predominant adverse event was also the occurrence of infection seven (58.3%), but followed by exteriorization three (25.0%) and occlusion two (16.6%). All catheters studied were removed.

Table 1 - Cost characterization variables in Reais and minimum and maximum value probabilities, Rio de Janeiro, RJ, Brazil, 2019.

Variable	Initial Value*	Minimum	Maximum
Cost			
Antibiotic Therapy	1209.8	99.2	1110.7
Length of Hospital Stay	15.0	4.8	27.2
Tray Sterilization	45.8	21.2	24.7
Field Sterilization	29.2	5.5	23.7
Blood Culture Collection	89.5	10.3	79.2
Catheter Removal	16.1	4.5	11.6
Catheter Dressing	19.8	7.4	19.0
Catheter Insertion (Double Lumen)	197.8	40.6	157.2
Catheter Insertion (Triple Lumen)	276.1	121.7	154.5

Variable	Initial Value*	Minimum	Maximum
Probability			
Double Lumen Adverse Event	0.6	0.5	0.7
Triple Lumen Adverse Event	0.8	0.7	0.9
Double Lumen Exteriorization	0.2	0.2	0.2
Triple Lumen Exteriorization	0.6	0.5	0.6
Double Lumen Occlusion	0.3	0.3	0.4
Triple Lumen Occlusion	0.2	0.1	0.2

*Inicial Value: standard real cost value of the studied hospital

The values of the procedures were calculated according to the standard operating protocols. These may suffer cost changes, being calculated the standard deviation for maximum and minimum. The antibiotic therapy variable presented the highest variation of the standard deviation. This may be justified by non-standardization of an antibiotic therapy protocol in the institution studied, due to a failure in the purchase process and availability of antibiotics in the sector or misconception in the therapeutic process prescription.

Figure 1 - Decision tree with probability and costs in Reais (R\$) of each included area, Rio de Janeiro, RJ, Brazil, 2019.

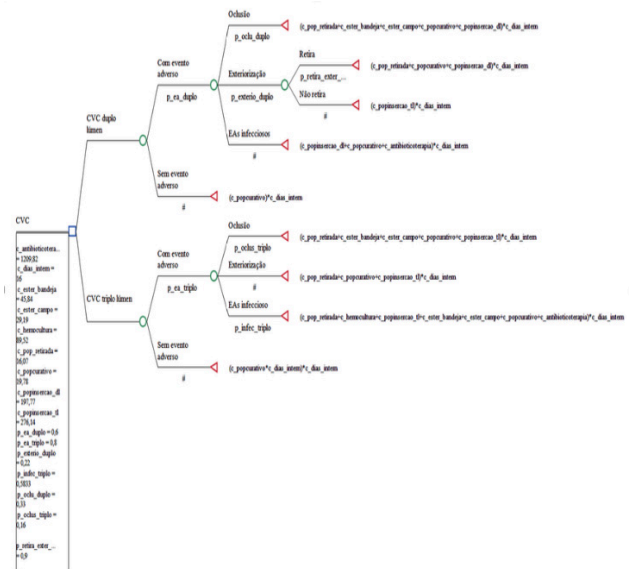


Table 2 - Cost ranking in Reais (R\$) generated by use of double lumen and triple lumen central venous catheter, Rio de Janeiro, RJ, Brazil, 2019.

Rank	Strategy	Value (R\$)	Incremental Value (R\$)
1	Triple lumen CVC	15,421.24	0
2	Double lumen CVC	7,773.01	7,648.22

From the analysis generated by the *TreeAge* software, it is evident that, for each triple lumen central venous catheter, an average of R\$15,421.25 was spent and, for double lumen, the average cost was R\$7,773.02. This cost difference was due to the higher probability of adverse events occurring in the triple lumen central venous catheter.

In the double lumen central venous catheter, the adverse event occlusion generated R\$4,938.40, externalization generated R\$12,744.05. In order to better present the data, a tornado diagram was developed through the *TreeAge* software to evaluate the impact of total cost variables on the scenario and sample analyzed.

From this diagram it was evident that the length of hospital stay of patients in an ICU was the factor that had the greatest impact on the generation of the total average cost, followed by the average cost of antibiotic therapy and the probability of adverse events in double lumen central venous catheter. It is important to highlight that the variation in the probability of adverse events occurring in the double lumen central venous catheter is higher than the variation in the occurrence of the triple lumen one, but the cost related to the triple lumen is much higher.

In view of the impact of hospitalization days on cost generation, a sensitivity analysis of the variable “cost” was performed between the double and triple lumen catheters per day. Sensitivity analysis aims to determine which risks have the greatest potential impact on the project. In this case, the variable referring to the length of hospital days presents an exponential growth of the triple lumen central venous catheter in relation to the double lumen one. This may be justified by the higher likelihood of adverse events occurring in triple lumen catheters.

DISCUSSION

In Brazil, discussions about adverse events began in 2002 with the creation of the Brazilian Sentinel Network of Hospitals by the Brazilian Health Regulatory Agency (ANVISA), which has voluntary participation and aims to notify adverse events and technical complaints regarding technovigilance, pharmacovigilance and hemovigilance^{9,10}.

A recent Brazilian study shows that the average length of ICU stay of 38.2 ± 28.8 days before the diagnosis of bloodstream-related infection, higher than that found in the present research⁹. Another study showed that the length of stay catheter longer than 10 days and in the ICU longer than 21 days are risk factors for central venous

catheter-related infection⁹⁻¹². Thus, the mean length of catheter stay found in the present study is below that reported in the literature.

Mechanical adverse events include central venous catheter obstruction. Obstruction is characterized by lumen occlusion due to blood clot formation or drug precipitate at the extremity inside the vessel, preventing infusion of the intravenous solution. Studies indicate that the incidence of obstructing thrombus ranges from 3% to 79% in central venous catheters. Signs of obstruction can be observed by stopping the infusion or when the alarm on the infusion pump occurs^{10,11}. A Spanish study demonstrates that the occurrence of obstruction is directly related to the number of lumens of the catheter, with an incidence of obstruction of 4.96%¹⁰⁻¹². In the present study, the incidence of occlusion in a double lumen central venous catheter was six (33.3%) and two triple lumen central venous catheter (16.6%), corroborating with the studies cited in relation to the higher incidence of obstruction or occlusion in triple lumen catheter over double lumen catheter.

Another common adverse event related to the use of central venous catheter is the occurrence of infection. The costs associated with infection are estimated to range from \$ 3,061 to \$ 40,000 per event. These data reinforce the importance of preventing bloodstream infection, as the results presented showed the high cost generated by adverse events, especially in the triple lumen catheter (58.3%).

A Chilean research found that the cost per event was US\$ 3,854,796 (US\$7,783), in which 94.5% of this value is associated with hospital stay¹²⁻¹⁴. These data corroborate the present research in which it was shown that the variable “length of hospital stay” was the most impacting influence of the costs generated.

To these monetary costs must be added personal costs, which are often incalculable, such as interruption of the patient’s clinical progress, delayed discharge, impossibility of timely reinsertion, family and psychological costs¹²⁻¹⁵.

In addition, the level of awareness of the patient using the catheter, such as in cases of delirium, agitation and patient fall may be causes for the occurrence of central venous catheter externalization.

Nursing is the main professional category responsible for the manipulation of these devices whose handling is based on clinical protocols. Catheter maintenance protocols should be established in partnership with the infection control service of the hospital to prevent infection of these instruments, with written routines available for consultation by professionals².

According to the Nurse Practice Act, private nurse activities include direct nursing care for critically ill patients, prevention of hospital-acquired infection and systematic control of harm that may be caused to clients during nursing care. This law supports the importance of nurses seeking ways to prevent possible incidents and to promote safety and effective care in the sector.

Failures in the care process are more common than we think because, unlike industrial production, health professionals do not assume human error, therefore do not work to create mechanisms to prevent it¹³⁻¹⁵.

Combined with this perspective, for the good performance, the development of a planning that considers the actions directed to the health care of individuals is necessary, delimiting the available and necessary resources, whether material, human or financial. In the health area, the rising costs have encouraged the search for rationalization in the allocation of resources and the balance between costs and financial resources, aiming at the effectiveness of care. Therefore, knowledge and skills in cost management are needed as a strategic tool to assist in the planning and decision making process. In this sense, it is noteworthy that nurses become health professionals with great potential to ensure quality care and with rational costs¹³⁻¹⁵.

It is understood that, in health services, there is a need to know costs, control expenses and eliminate waste, without prejudice to quality, efficient distribution of resources, ensuring the provision of qualified services and compatibility between costs and budgets.

CONCLUSION

The research was able to produce evidence that can assist health managers in making decisions related to hospital cost reduction. The study found that there are more costs related to adverse events with the triple lumen central venous catheter compared to the double lumen central catheter, due to the higher probability of the events exposed in the survey. Since nursing often manipulates central venous catheter, whether in dressing or manipulating the catheter, care should be taken to select the right device and identify early adverse events.

The research allowed us to describe how important it is to perform a cost minimization analysis in an attempt to guide managers in decision-making and, consequently, bring benefit to the whole society.

Another issue that brings us to reflection is the usability of hospital medical equipment and its close relationship with patient safety. We hope that the research data can support the adoption of adverse event preventive measures related to the appropriate use of equipment and devices intended for intravenous infusion of medications.

It is recommended that nursing participate in the decision regarding the choice of the ideal catheter according to the patient profile, aiming to minimize the occurrence of mechanical and infectious adverse events and providing the purchase of the ideal quantity and availability according to the demand of the sector.

The main limitations of the study were incomplete information in medical and nursing records in medical records, reduction of human resources due to the crisis in the state of Rio de Janeiro at the time of data collection,

scarcity of data in the literature on costs related to central venous catheter and mechanical adverse events. No studies were found on the cost difference in central venous catheter in different lumens.

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