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ORIGINAL ARTICLE

DIRECT COST OF CENTRAL VENOUS CATHETER INSERTION FOR CONVENTIONAL HEMODIALYSIS

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ABSTRACT

Objective: to identify the average direct cost of long-term central venous catheter insertion in patients undergoing conventional hemodialysis in a public teaching and research hospital.

Method: quantitative, exploratory-descriptive research, conducted in a Dialysis Center in São Paulo, Brazil between November and December/2019. The average direct cost was calculated by multiplying the time spent by health professionals by the unit cost of direct labor, adding to the costs of inputs.

Results: The average total direct cost was US$134.56 (SD±3.65), of which US$107.01 (SD±0.23) for material costs, US$22.10 (SD±3.63) for direct labor of the catheter insertion team, US$4.65 (SD±0.00) for medication costs, and US$0.80 (SD±0.15) for solution costs.

Conclusion: the impact of costs with material resources and the indispensability of their rational allocation was verified, especially in public teaching and research hospitals, which have limited financial resources.

DESCRIPTORS: Renal Insufficiency, Chronic; Hemodialysis Units, Hospital; Nephrology Nursing; Catheterization, Central Venous; Costs and Cost Analysis.

COSTO DIRECTO DE LA INSERCIÓN DE CATÉTER VENOSO CENTRAL PARA REALIZACIÓN DE LA HEMODIÁLISIS CONVENCIONAL

RESUMEN:

Objetivo: identificar el costo directo de la inserción de catéteres venosos centrales de larga duración en pacientes sometidos a hemodiálisis convencional en un hospital público de enseñanza e investigación. Método: investigación cuantitativa exploratoria-descriptiva realizada en un Centro de Diálisis de São Paulo, Brasil, entre noviembre y diciembre/2019. El costo directo medio se calculó multiplicando el tiempo empleado por los profesionales de la salud por el costo unitario de la mano de obra directa, sumando los costos de los insumos. Resultados: el costo directo medio total fue de 134,56 dólares (SD±3,65), de los cuales 107,01 dólares (SD±0,23) fueron costos de material, 22,10 dólares (SD±3,63) fueron costos de mano de obra directa del equipo de inserción de catéteres, 4,65 dólares (SD±0,00) fueron costos de medicación y 0,80 dólares (SD±0,15) fueron costos de solución. Conclusión: se ha constatado el impacto de los costos de los recursos materiales y la importancia de su asociación racional, especialmente en los hospitales públicos de enseñanza e investigación, que cuentan con recursos financieros limitados.

DESCRIPTORES: Insuficiencia Renal Crónica; Unidades de Hemodiálisis en Hospital; Enfermería en Nefrología; Cateterismo Venoso Central; Costos y Análisis de Costo.

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INTRODUCTION

In Brazil, the increased prevalence of patients with chronic kidney disease (CKD) has become a major public health problem [1], similarly to what occurs in other countries [2]. The incidence of CKD has increased due to the growing number of diabetic and hypertensive individuals and the aging population [2].

CKD occurs silently and sufferers may discover its existence only in more advanced stages, which require the adoption of a modality of Renal Replacement Therapy (RRT). The indicated treatment varies according to the stage of CKD, and may be conservative, with the use of diet and drugs; dialysis, through hemodialysis (HD) or peritoneal dialysis (intermittent, continuous ambulatory, automated); or by performing renal transplantation[3].

Conventional hemodialysis (CHD) has been traditionally adopted for decades, especially for the most advanced stages of CKD [4]. In Dialysis Centers (DCs), the care provided to patients in the CDH program encompasses complex procedures and actions, requiring resources that comply with the legal provisions in force [5-6]. It requires the use of specific solutions, materials and equipment, availability of a specialized team during the entire treatment, appropriate physical structure and efficient vascular access (VA) to the blood circulation [7].

The success of CHD is causally related to the adequacy of the VA [8], which can be obtained by means of an autologous Arteriovenous Fistula (AVF), a prosthetic arteriovenous graft or by insertion of a central venous catheter (CVC) [9]. It is noteworthy that the VA must be easy to use, have good blood flow, low resistance in venous return, guaranteed durability and low probability of hemorrhagic accidents, coagulation and infection [8].

In front of the occurrence of complications that compromise/impair the use of the VA and, consequently, make the CHD session unfeasible, it becomes necessary to adopt some immediate intervention, such as the insertion or reinsertion of a CVC, generating costs that need to be identified and properly managed.

In the managerial dimension, the determination of health services costs is essential to direct the rational allocation of consumed inputs [10]. However, studies on costs related to procedures for the management of complications associated with VA for CHD are still scarce, especially in the national context, as can be seen in relation to the insertion procedure of long-term CVC. Research of this nature can generate new knowledge about the costs associated with rescue interventions to enable CHD and assist in the identification, monitoring and management of costs in the care practice of DCs.

In this perspective, this study was carried out with the objective of identifying the average direct cost of the insertion of a long-term central venous catheter in patients undergoing conventional hemodialysis in a public teaching and research hospital.

METHOD

Quantitative, exploratory-descriptive research, in the form of a single case study, carried out in the DC of a Public Teaching and Research Hospital (HPEP), which is an autonomous entity under a Special Regime, associated to a Public University maintained by the State of São Paulo and linked to the State Secretariat of Economic Development, Science and Technology, through one of its Teaching Units.

The DC fully complies with the legal provisions regarding the adequate technological

structure and the quantitative-qualitative human resources necessary to meet the demands of care for CKD patients in the CHD program [9-10]. It has 24 machines for CHD and serves 118 patients allocated in three shifts from Monday to Saturday. The team consists of Nephrology residents and preceptors, nurses and nursing technicians/assistants (NT/NA), nutritionist, psychologist, and social worker.

At the HPEP, it is standardized that the insertion of long-term CVCs, as an access route to enable CHD, is performed by a resident physician, under the supervision of a preceptor, both in the Nephrology area, and with the help of a NT/NA from the DC.

Considering that there is no variation in the quantity of human resources (resident physician, preceptor physician, and NT/AN) involved in the long-stay CVC insertion procedure and little variation in the quantity of consumed inputs (materials/medicines/solutions), a professional statistician established that only a few observations would be sufficient to obtain the average direct cost (ADC). Thus, the convenience sample corresponded to the opportunities of direct, non-participant observation of the procedure under study, performed at HPEP in the morning and afternoon periods, between November and December 2019.

Non-participant observations were made to document the number and category of health professionals involved in the insertion/aid for insertion of long-stay CVC; the time (timed) spent by them; the materials/medicines/solutions and quantities used in the procedure. To obtain the average direct cost of this procedure [$\overline{C(P_i)}$], a micro-costing study was carried out whose reference will consist in the calculation of direct costs.

Direct costs are those that can be identified and clearly quantified; they refer to a monetary expenditure applied in the production of a product or service in which identification with the product or department is possible [11]. In hospitals, direct costs are composed of direct labor DL, inputs, and equipment used in the care process [12].

The DL refers to the personnel who work directly on a product/service provided, as long as it is possible to measure the time spent and identify who performed the work. It is composed of salaries, social charges, provisions for vacation and 13th salary [11]. The unit cost of Direct Labor was calculated from the average salaries of NT/NA of the DC and values of the scholarships of resident physicians and Nephrology preceptor physicians provided by the Human Resources Service of HPEP.

The prices of the materials and solutions/medicines consumed in the insertion of the long-stay CVC were obtained from the Purchasing Department/Warehouse at HPEP.

To determine the average quantity of materials [$\overline{C(P_i)}$]; the average unit price of each material [$\overline{qm_k}$]; the average unit price of each material [$\overline{Pmu_k}$]; the average quantity of solutions/medications [$\overline{qs_k}$]; the average unit price of each solution/medication [$\overline{Psu_k}$]; the average time of dedication of each professional category [$\overline{t_c}$] and the average unit wage bill of each professional category [$\overline{Su_c}$], obtaining the equation: $\overline{C(P_i)} = \sum_{k=1}^{n} (\overline{q_k} \cdot \overline{Pu_k}) + \sum_{k=1}^{n} (\overline{qs_k} \cdot \overline{Psu_k}) + \sum_{c=1}^{n} (\overline{t_c} \cdot \overline{Su_c})$ [10].

To calculate the MDC of the long-stay CVC insertion, we originally used the Brazilian Real (R$) currency, which was later converted to the US dollar (US$) considering the conversion rate of US$ 1.00/R$5.46, based on the exchange rate of 02/01/2021, provided by the Central Bank of Brazil.

The study was approved by the Ethics and Research Committees of the proposing institution and HPEP by means of the consubstantiated opinions numbers: 3,324,582, on 05/14/2019 and 3,373,665, on 06/06/2019, respectively.

RESULTS

Between November and December 2019, 11 observations of long-stay CVC insertion were performed. The average salaries received by the professionals integrating the procedure corresponded to preceptor physician (preceptorship stipend and food voucher) - US$1056.49/160 hours, US$6.60/hour and US$0.11/minute; resident physician (residency stipend) - US$609.97/240 hours, US$2.54/hour and US$0.04/minute; and NT/AN (salary mass: base salaries, benefits, gratuities and social charges) - $873.02/120 hours, $7.27/hour and $0.12/minute.

With respect to costs of inputs used, Table 1 shows the predominance of the items Kit CDL-LP carbothane 14.5fr, 28 cm for HD (unit) - US$103.48; Heparin sodium 5000 IU/ml solution for injection (IV) (bottle 5ml) - US$2.66; Cefazolin powder solution for injection (1gram bottle) - US$0.92; Lidocaine (hydrochloride) 2% solution for injection (20ml bottle) - US$0.47 and Sodium chloride 0.9% solution for injection (100ml bag) - US$0.23.

Chart 1 - Distribution of costs of materials and solutions/medicines used in the long-term CVC insertion procedure. São Paulo, SP, Brazil, 2020 (continues)

Material and solution/medicament (presentation)	**Estimated cost/cost* in US$**
Disposable hypodermic needle 30x7, with safety device (unit)	0,03
Disposable hypodermic needle with blunt tip (unit)	0,01
Cotton ball (unit)	0,004
Disposable oxygen catheter with spectacle-like nasal extension (unit)	0,24
Sterile gauze dressing 7,5x7,5cm without radiopaque filaments (package)	0,06
Equipment for the administration of parenteral macro-drops solution with lateral infusion injector 150cm (unit)	0,15
Disposable brush with chlorhexidine degerming 2% (unit)	0,25
3/0 nylon thread, with 1 3/8 needle, triangular circle 3/0 cm diameter, 450 cm long (envelope)	0,19
Adhesive surgical tape of rayon (roll 10cmx450cm)	2.49 (roll 10cmx450cm) 0.8 (15cm/procedure) *
Kit CDL-LP carbothane 14,5fr, 28 cm for HD (unit)	103,48
Disposable scalpel blade (pair)	0,37
Sterile surgical procedure glove (pair)	0,11
Synthetic gloves (nitrile), for procedures, non-surgical, non-sterile (pair)	0,05
Disposable surgical mask (unit)	0,02
Disposable syringe 10ml (unit)	0,04
Disposable Syringe 20ml (unit)	0,06
Disposable syringe 3ml (unit)	0,02
Disposable syringe 5ml (unit)	0,02
Disposable surgical cap (unit)	0,01
Sodium chloride 0.9% 10ml (unit)	0,02
Sodium chloride 0.9% solution for injection (100ml bag)	0,23

Alcoholic chlorhexidine 0.5% (100ml bottle)	0.31 (bottle 100 ml) 0.06 (20ml/procedure)*
Cefazolin powder solution for injection (1gram vial)	0,92
Fentanyl (citrate) 0.05 mg/ml solution for injection (ampoule 5 ml)	0,4
Heparin (sodium) 5000 IU/ml solution for injection (IV) (vial 5ml)	2,66
Lidocaine (hydrochloride) 2% solution for injection (bottle 20ml)	0,47
Midazolam 5mg/ml solution for injection (ampoule 3ml)	0,21

Source: Authors (2020)

The duration of the 11 "insertion of a long-stay CVC for HD" procedures ranged from 63.00 to 111.00 minutes, with a mean of 81.55 (SD±13.39) and a median of 79.00 minutes.

Table 1 shows that the total MDC was US$134.56 (SD±3.65), and the cost of material (US$107.01 - SD±0.23) was the variable with the highest impact (79.52% of the total MDC), with the CDL-LP carbothane kit being the item with the highest unit cost (US$103.48). It is also noteworthy the representativeness of the Direct Labor cost of the long-stay CVC insertion team (US$22.10 - SD±3.63) in the composition of the total CDM (16.42%).

Table 1 - Distribution of observations of the procedure "insertion of long-stay CVC for HD" considering the costs of the variables under analysis. São Paulo, SP, Brazil, 2020

Observations	n	Average US$	SD± US$	Median US$	Minimum and maximum values US$
Cost with DL of NT/AN*	11	9,56	1,57	9,26	7,38 - 13,01
Cost with DL of resident physician**	11	3,58	0,59	3,47	2,77 - 4,88
Medical DL preceptor cost***	11	8,96	1,47	8,68	6,92 - 12,20
DL cost of the long-stay CVC insertion team	11	22,1	3,63	21,27	17,08 - 30,09
Cost with materials	11	107,01	0,23	107,09	106,53 - 107,27
Cost with medications	11	4,65	0	4,65	4,65 - 4,65
Cost with solutions	11	0,8	0,15	0,73	0,62 - 1,06
Total MDC	11	134,56	3,65	133,81	130,07 - 143,00

*DL: NT/NA: US$0.12/minute; ** DL resident physician: US$0.04/minute; *** DL preceptor physician US$0.11/minute.
Source: Authors (2020)

DISCUSSION

To obtain better results regarding the VA for HD, the patient's physical aspects and lifestyle, the goals, the circumstances of the VA creation, the infrastructure and the culture/

philosophy about the VA in the DCs must be considered [13]. In this view, the creation and maintenance of the VA, aiming at the efficiency of HD and quality of life of the patient, impact the costs attributed to CKD, contributing to the financial burden associated with this modality of RRT [14].

The 11 long-term CVC passages observed in this study were performed by resident physicians, under the supervision of a preceptor, both from the nephrology area, and aided by a NT/AN of the DC, as standardized in the HPEP. There were no variations in the number and categories of professionals involved, as well as in the quantity of materials used; there was only little variation in the time spent. This finding shows that, because it is a HPEP, the cost with the team for insertion of the long-stay CVC is consistent with what is expected and shows the rational allocation of human and material resources involved, consistent with the principles, values and philosophy of institutions of this nature.

The standardization of procedures favors the implementation of practices with higher safety rates, ensuring reliability of the assistance provided, allowing the organization of work processes, the management of care provided, and providing support to health professionals by creating a favorable environment for teaching [15]. The essential contribution of the standardization of inputs to be used in procedures stands out, in order to avoid the occurrence of waste that compromises the distribution of limited and scarce resources.

This fact can be observed in Canada that, since 2011, has undergone the implementation of hospital financing reforms with the aim of encouraging the standardization of procedures, defining a fixed price for each hospital procedure, based on scientific evidence and costing studies, improving the quality of care and reducing/minimizing the costs of the health system [16].

Considering the rational allocation of resources in order to increase the care process, it is important to consider that the present study was carried out in a HPEP, whose definition explains that these are institutions that offer highly complex medical assistance and that perform, besides teaching, research, and community outreach activities, the training of health professionals at the primary, secondary, and tertiary levels [17].

Thus, the execution of the procedure "insertion of a long-term CVC" by the resident physician meets the mission of a HPEP, being considered an appropriate strategy in that it contributes to reducing the demands for health services and to increasing the quality of care, by scientifically modeling the recommended activities through the association between service, teaching, and research [18].

In a scenario of increasing hospital expenditures, coupled with the scarcity of financial resources, the relevance of cost control has become increasingly evident [19]. In Brazil, financial, material and human resources are scarce and limited, requiring, in recent years, several initiatives to integrate scientific evidence in the collective decision-making process[20].

The development of cost surveys to evaluate healthcare procedures is crucial due to the change in the healthcare profile, strong technological inclusion and the presence of emerging diseases [21]. Therefore, the generation of cost information is essential for the management of health resources, supporting institutional decision-making processes, monitoring and evaluation. However, there is still a scarcity of cost information bases in Brazil, being limited to only a few institutions [21]. In turn, the dynamics of technological innovation has been recognized as one of the reasons for the increase in health expenditures and is one of the biggest challenges to be faced in the Unified Health System (SUS) [22].

Understanding the relevance of proper economic monitoring, SUS created the *Sistema de Gerenciamento da Tabela de Procedimentos, Medicamentos, Órteses, Próteses e Materiais Especiais* (SIGTAP) (Management System of the Table of Procedures, Medicines, Orthoses, Prostheses, and Special Materials), a management tool that allows to systematically monitor, through historical series, the changes occurred in each competence

included in the system. It enables the generation of several reports, providing monthly technical notes, registering the main changes made in the Table of Procedures [23]. However, the values practiced by this Table, even after readjustments (which do not occur frequently), do not follow the intrinsic inflation of the health sector, whose prices grow more than the economy in general.

Comparing the values passed on by SUS to HPEP, contained in SIGTAP(24) for "hemodialysis indwelling catheter" (R$ 482,34) and "hemodialysis indwelling catheter implant" (R$ 200,00) with the costs measured in this study, CDL-LP carbothane HD Kit (R$565, 00 - US$103.48) and passage of the hemodialysis long-term catheter (R$169.72 - US$31.09), the difference is R$82.66 less (US$15.14) and R$30.28 more (US$5.54) respectively, totaling a coverage deficit of R$52.38 (US$9.60) per passage of the long-term catheter. Given this result, we agree with a study (25) that explains that knowledge of the coverage deficit has the potential to support the negotiation between the HPEP, contracted with the SUS, and the state or municipal manager for adjustments of the financial transfer.

In this study, it was possible to observe that the carbothane CDL-LP Kit for HD was the item with the highest unit cost, standing out in relation to the cost of material used to perform this procedure. The use of long-term CDL is considered pertinent considering that, under the unique perspective that nephrologists have in relation to dialysis, the implantation of this type of catheter has shown effective and safe results for the patient submitted to HDC [26].

Even though the cost of materials was the most expressive in the composition of the total ADC of the insertion of a long-term CVC insertion for HD, similarly to the results of other studies on the costing of hospital procedures [27-29], we reiterate the undeniable contribution, as previously mentioned, of the standardization of the inputs to be used in the procedure. It is also highlighted that, due to the representativeness of the costs with material resources, the hospital institutions, both public and private, need to make investments with respect to the appropriate management of these resources, a basic aspect that offers the possibility of reducing costs and losses to the national health budget [30].

As a limitation of this study, the option for the direct costing of the procedure in question is indicated, given the impossibility of obtaining information from HPEP regarding the indirect costs that would allow the measurement of the total cost.

CONCLUSION

The total ADC of the procedure "insertion of a long-term CVC for HD" corresponded to US$134.56 (SD±3.65), being 79.52% related to material costs, 16.42% to DL of the CVC insertion team, 3.46% to drug costs and 0.6% to solution costs. We conclude, therefore, that material resources have a high impact on the composition of the cost of this procedure, and it is evident the indispensability of its rational allocation, especially in HPEP, which have limited budget resources.

As a contribution to professional practice, this study gave visibility to the financial aspects related to the "insertion of long-term CVC for HD", a procedure used for the management of complications associated with VA for CHD. Despite recurrent searches of national and international literature, no similar studies were found to enable the verticalization of the discussion about the economic knowledge produced. The lack of productions of this nature indicates the need for similar research in other HPEP and private hospitals.

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