Cost analysis of a medical procedure using the full cost method: The example of a trans-thoracic scan-guided biopsy

Analyse du coût d'une procédure médicale par la méthode des coûts complets : La biopsie trans-thoracique scanno-guidée comme exemple

Hela Cherif[1,5], Fatma Hamza[2], Salma Mokaddem[1,5], Aida Ayadi[3,5], Saoussen Hantous[4,5]

1. Pulmonology Department, Internal Security Forces Hospital, «Health and Environment in Security Forces « Research Laboratory LR21INT01.
2. Faculty of Medicine of Sfax, University of Sfax, Tunisia
3. Pathology Department, Abderrahmane Mami Hospital, Ariana, Tunisia.
4. Imaging Department, Abderrahmene Mami Hospital, Ariana – Tunisia.
5. Faculty of Medicine of Tunis, University Tunis El Manar, Tunisia

Abstract

Background: Trans-thoracic scan-guided biopsy (TTB) is a crucial examination for exploring thoracic lesions, particularly in the case of tumor pathologies. To make informed decisions in cost-effectiveness analyses, it is important to understand the actual costs of this procedure.
Aim: To quantify the cost of performing TTB using a microeconomic approach.
Methods: We used the full cost method, which is the reference method in cost accounting. This method subdivides costs into direct and indirect costs. Direct costs are divided into variable and fixed components. Variable costs include consumables and wages of personnel involved in the «labor» act. Fixed direct costs are those that do not vary during the study period; they include the costs of purchasing, depreciation, maintenance, and repair of the scanner room equipment. Indirect costs include overhead costs that cannot be directly attributed to the TTB procedure.
Results: The total direct cost of the TTB procedure amounts to 310.191 TND when using a coaxial and 256.390 TND in the absence of a coaxial, including fixed and variable costs. Indirect costs were not included in this study due to the absence of cost accounting at the hospital.
Conclusion: Accurate knowledge of the costs of any medical procedure is essential for making informed decisions in cost-effectiveness analyses. This study provides a precise estimate of the direct costs of TTB and can help improve the efficiency of resource allocation for performing this procedure.

Key words: costs and cost analysis; Image-Guided biopsy; health care economics and organizations

Résumé

Introduction: La biopsie trans-thoracique scanno-guidée (BTP) constitue un examen clé pour l'exploration des lésions thoraciques notamment dans le cas de pathologies tumorales. Afin de prendre des décisions éclairées dans les analyses de coût-efficacité, il est important de comprendre les coûts réels de ces procédures.
But: Quantifier de manière exhaustive le coût de réalisation de la BTP en utilisant une approche microéconomique.
Méthodes: Nous avons utilisé la méthode des coûts complets, qui est la méthode de référence en comptabilité analytique. Cette méthode subdivise les coûts en coûts directs et indirects. Les coûts directs se divisent en composantes variables et fixes. Les coûts variables comprennent les consommables et les salaires du personnel impliqué dans l'acte «main d'œuvre». Les coûts directs fixes sont ceux qui ne varient pas pendant la période de l'étude ; ils comprennent les coûts d'achat, d'amortissement, d'entretien et de réparation du matériel de la salle de scanner. Les coûts indirects comprennent les coûts généraux qui ne peuvent pas être attribués directement à la procédure de BTP
Résultats: Le coût direct total de la procédure de BTP s'élève à 310,191 TND en cas d'utilisation d'une coaxiale et de 256,390 TND en absence d'utilisation d'une coaxiale, comprenant les coûts fixes et variables. Les coûts indirects n'ont pas été inclus dans cette étude en raison de l'absence de comptabilité analytique à l'hôpital.
Conclusion: Une connaissance précise des coûts de toute procédure médicale est essentielle pour prendre des décisions éclairées dans les analyses coût-efficacité. Cette étude fournit une estimation précise des coûts directs de la BTP et peut aider à améliorer l'efficacité de l'attribution des ressources pour la réalisation de cette procédure.

Mots clés: Coûts et analyse des coûts, Biopsie guidée par l'image, Organisations et économie des soins de santé.

Correspondance
Hela Cherif
Pulmonology Department, Internal Security Forces Hospital,Tunisia
Email: hela_cherif@hotmail.com

INTRODUCTION

In the current context of healthcare resource management, the cost of diagnostic and therapeutic procedures is increasingly being taken into consideration. Healthcare professionals must therefore be aware of the importance of health economics to evaluate the profitability of each act and maximize the use of available resources. However, determining the real costs of a procedure is a complex task that requires a thorough and rigorous investigation to take into account the different direct and indirect elements associated with it, such as the cost of consumables, labor, depreciation and maintenance of equipment, administrative fees, taxes, overhead costs, as well as any other charges related to the procedure.

The objective of this study is to exhaustively quantify the costs associated with the performance of trans-thoracic biopsies (TTB), an interventional radiology procedure, using detailed microeconomic analysis. This model can be easily adapted to different types of institutions and practices.

METHODS

This retrospective study included 65 consecutive TTBs in 61 patients performed at the Aberrahmane Mami Hospital imaging department between January and June 2019. We used the full cost method, which is the reference method of cost accounting and allows costs to be subdivided into direct and indirect costs (Figure 1). Direct costs are further divided into variable and fixed components. Variable costs include the cost of consumables and the salaries of personnel involved in the act (labor). Direct fixed costs, on the other hand, are those that do not vary during the study period and include the costs of purchase, depreciation, maintenance, and repair of the scanner room equipment.

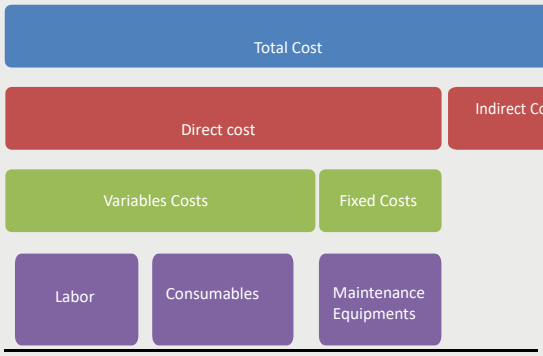

Figure 1. Full cost structure

The scanner room is a component of the medical imaging department, which is itself part of a hospital-university structure. Therefore, there are costs directly and indirectly associated with the scanner room. Direct costs are the expenses generated inside the scanner room to perform a given procedure. Indirect costs, on the other hand, are shared with other departments such as general maintenance of the facility, administration, security, etc.

The cost of consumables used during procedures was tracked from the product use software available at the hospital pharmacy. Labor costs and fixed costs were available in our accounting system. All amounts were expressed in Tunisian Dinar (TND).

To simplify the cost analysis, it is appropriate to subdivide this cost study into three distinct parts:

The cost of labor per procedure, including the wages and social charges of employees directly assigned to the scanner room, such as radiologists, interns in radiology, nurses, radiology technicians, secretaries, and workers. Costs were converted to an hourly rate for a trans-parietal scan-guided biopsy. The medical and paramedical components were calculated separately by adding the respective labor costs of the various personnel required for the procedure.

The overall operating costs of the scanner room, are independent of the procedure.

Fixed costs were evaluated based on the unit fixed costs of performing a scan and included depreciation costs as well as scanner room maintenance fees. Fixed costs notably include the amortization of the initial investment in equipment and the construction costs of the scanner room. The evaluation of equipment value was based on the theory of analytical accounting, taking into account the initial cost adjusted for depreciation. Maintenance costs are covered by an annual contract, including labor costs, major parts, and routine operations.

Indirect costs include radiology and pharmacy administration costs, as well as general maintenance costs of the service.

For data processing and descriptive analysis, Microsoft Excel 2010 software was used.

RESULTS

The total cost of a CT-guided biopsy consists of two elements: direct cost and indirect cost. The direct cost is the sum of fixed charges and variable charges. In our study, the variable cost included labor costs, consumables, and electricity consumption.

The cost of labor was calculated for each category of personnel involved, by normalizing the gross salary of the worker and their social charges based on a 36-hour workweek. For instance, the cost of medical labor was calculated taking into account the average gross salary, bonuses, and allowances provided by the law for the seven radiologists in the radiology department. The cost of paramedical labor was estimated based on the gross salaries of each category of personnel.

Cost of medical labor

The average gross salary (base salary plus bonuses and allowances provided by law for the seven radiologists in the radiology department) totaled 5000 TND per month. The hourly cost of the radiologist was 32 TND. The gross salary of radiology residents was 1800 TND per month. The hourly cost was 11.5 TND. The total medical component was, therefore, 43.5 TND per hour of the procedure.

Cost of paramedical labor

The gross salaries of the nurse, radiology technician, secretary, and laborer were 1300 TND, 1400 TND, 1300 TND, and 800 TND per month, respectively. The hourly cost was estimated at 8.33 TND, 8.97 TND, 8.33 TND, and 5.06 TND, respectively. The total paramedical component per hour of the procedure was then 23 TND

The total direct cost of labor was 74.36 TND per hour for the procedure. The average duration of a CT-guided biopsy, which includes the actual procedure time, patient preparation, and report writing, is one hour. The total cost of labor for a CT-guided biopsy is 74.36 TND per intervention, which includes the costs of the radiologist, resident, radiology nurse, technician, and laborer.

The cost of consumables for CT-guided biopsy included the cost of biopsy needles, the cost of equipment used (20G access routes, gloves, fields, etc.), and the cost of

electricity. During our study, only one needle was used per procedure. The average cost of consumables per biopsy was 168.631 TND in the case of a coaxial needle (Table 1) and 115.081 TND in the absence of a coaxial needle.

Table 1. Details of the cost of equipment necessary for the procedure.

Materials	Numbers	Unit price (TND)	Consumables price (TND)
Biopsy needle	1	107.650	107.650
Coaxial	1	53.550	53.550
Calot	1	0.052	0.052
Scalpel blade	1	0.2	0.2
Sterile compresses pack of 5;12ply 8*7	2	0.272	0.544
10cc syringe	1	0.277	0.277
20G cannula	1	0.75	0.75
Pair of gloves	2	0.985	1.97
Simple drape	1	1	1
Fenestrated drape	1	1.2	1.2
2% Lidocaine (box of 10) 2 ampoules	2	0.163	0.327
Formaldehyde (1 liter)	0,02	3.658	0.073
Neoplast perforated adhesive tape	0,01	5.636	0.056
Betadine (500ml bottle)	0,20	6.548	1.309
TOTAL			168.631

Regarding electricity consumption, the average consumption per procedure is 50 kWh, with an average cost of 0.296 TND per kWh billed by STEG. The average time required to perform a CT scan acquisition is 30 minutes, and the average electrical consumption per procedure was 50 kWh. The total cost of electricity consumption for each biopsy was 14.8 TND.

Fixed cost

The CT scanner's fixed cost includes not only the acquisition cost but also the costs of the scanner room's construction, such as civil engineering, air treatment, and electricity. The actual cost of our Siemens Somatom Definition AS 64-slice 128-detector scanner was 1 610 152 TND. In addition to this, there were construction costs of 330 000 TND for the scanner room, which included civil engineering, air treatment, and electricity, as well as user training costs totaling 13 184 TND and technical training costs totaling 16 924 TND. The total cost amounted to 1 970 260 TND. This cost is amortized over 10 years.

In addition to depreciation, the annual cost of the maintenance contract amounts to 106 000 TND, constituting the total annual operating cost of the CT scanner room. This cost is then divided by the total number of scans performed annually, which amounted to 5780 exams in 2018, to determine the direct fixed cost of a computed tomography scan. Thus, the direct fixed cost was 52.4 TND /CT scan (Table 2).

Table 2. Details of fixed costs

Fixed Costs/Procedure	TND
Depreciation	27.8
Maintenance and Training	18.8
Amortization of premises	5.7
Fixed Cost/Procedure	52.4

In the absence of analytical accounting at the hospital, indirect costs could not be obtained.

Total Cost

The total cost of the CT scanner, including fixed and variable costs, was 310.191 TND with a coaxial and 256.390 TND without a coaxial. (Table 3).

Table 3. Total cost of TTB

	Direct Cost						Indirect Cost	Total Cost
	Charges variable			Charges fixes				
	Consumables	Labor	Electricity	Depreciation	Maintenance	Amortization of premises		
TTB using a coaxial (TND)	168.631	74.36	14.8	27.8	18.8	5.7	-	310.191

DISCUSSION

The present study aimed to comprehensively evaluate the cost of performing an interventional radiology procedure using a microeconomic approach. The proposed model is easily adaptable to various types of institutions and practices. The approach adopted in this study seeks to provide a clear and explicit delimitation of the different cost components and their respective amounts.

The cost accounting methods used by economists were followed (1), and a previously reported algorithm was used to first consider the categories of direct and indirect costs (2,3).

By dividing costs based on hospital, department, and section elements for each procedure, it is possible to calculate the actual operating costs of the imaging service, which can then be converted into actual costs of specific procedures.

Indirect costs are usually fixed, but direct costs must be divided into fixed and variable components (3,4). The distinction between variable and fixed costs may depend on the time horizon of the study (5). The indirect cost of a procedure such as a CT scan includes all expenses (such as salaries for administrative, security, cleaning staff, and hospital depreciation) that are not directly related to the performance of the examination (1). In the context of healthcare, indirect costs refer to the unmeasured effects of a disease, including tangible effects like psychological effects and intangible ones like lost productivity at work. In economic studies, the term «indirect cost» should correspond to the study's perspective, particularly in healthcare, where it refers to non-medical effects of illness (e.g., treatment-related work absenteeism) (6), as opposed to the indirect cost of a procedure, which includes additional costs such as staff salaries and hospital upkeep.. For accurate interpretation within both economic and medical frameworks, it is crucial to understand this distinction.

In most institutions, the CT unit is part of the radiology department and, as such, operates as an individual unit while sharing resources and responsibilities with the radiology service and the hospital (7). The cost of shared resources is part of the indirect cost component of the procedure.

The costs associated with a one-time intervention whose effects would not extend long-term do not require a long-term study (8). Thus, in our study, the fixed costs of the scanno-guided biopsy were calculated using the unit fixed cost of performing a scan. Equipment usage is limited by its lifespan, which is estimated by the duration of amortization. According to the High Council for the Future of Health Insurance (HCAAM), the amortization period for heavy imaging equipment is 7 years (9). In our study, the amortization period was estimated at 10 years, in line with

the duration considered by the Ministry of Health in Tunisia for the renewal of heavy imaging equipment.

The use of procedure time as a factor in labor cost accounting was considered valid for several reasons. Labor cost is an important factor, estimated at 40% of the procedure cost in most studies (3,4). However, in our study, it represented only 24% of the total cost due to the underpayment of healthcare personnel in our country.

Each medical service is subject to a professional acts key, which allows for standardized billing. These keys must be included in a decree from the Ministry of Health, which is required to be published in the Official Journal of the Tunisian Republic JORT (10). The act of transcutaneous biopsy with scan guidance is defined according to the nomenclature of health professions acts by the 'KE'50 key. The KE key corresponds to a specialty act performed by a physician within the limit of their competencies. The amount of the KE key was set at 1.2 TND by the Ministry of Public Health decree published in JORT in 1996 (11) and was not revised by the 2008 decree (12). Thus, the cost of the radiologist's labor during the transcutaneous biopsy with scan guidance is equal to 60 TND. This amount corresponds to the hospital's billing for the physician who performed the biopsy. The total cost of the medical component in our study was 43.5 TND per transcutaneous biopsy with scan guidance. Furthermore, this procedure is not listed in the rates of medical acts covered by the National Health Insurance Fund (CNAM) (13).

In France, transcutaneous biopsy with scan guidance costs € 246.09 (14), three times the cost determined by our study, although we used the same consumables. This disparity is mainly explained by the difference in labor costs.

In Italy, interventional and diagnostic radiology is considered a subspecialty, benefiting from a regulatory framework, adequate training, and quality assurance programs. Acts are segmented according to their nature. In the United Kingdom, although interventional radiology is practiced only by radiologists, it does not benefit from a specific regulatory framework. The Royal College of Radiologists (RCR) publishes guidelines without binding force and offers specialized training. Moreover, the British Society of Interventional Radiology (BSIR) has developed a medico-economic guide for managing human resources in interventional radiology (15).

In Tunisia, to date, interventional radiology does not benefit from a specific regulatory framework. A revision of the hospital nomenclature is underway to establish an exhaustive list of acts and value them for reimbursement based on an objective evaluation of their cost. The re-evaluation of the costs of medical procedures is both necessary and urgent as part of Tunisia's overall policy to save public health. The various parties involved, including doctors, administrators, and politicians, must collaborate to implement a continuous cost evaluation system that is responsive to external variables such as inflation, currency rates, and labor cost fluctuations.

It should be noted that this study has certain limitations. The calculated cost of the procedure is that of direct cost, as the indirect cost could not be obtained due to the absence of analytical accounting in the hospital. Indirect costs constitute a substantial portion of the overall cost structure within healthcare systems. By not incorporating these costs into our analysis, we acknowledge the potential distortion of the true economic impact of the trans-thoracic scan-guided biopsy procedure. The consequences extend to the interpretation of cost-effectiveness, as our assessment may underestimate the financial burden on healthcare facilities and fail to provide a complete picture of resource allocation requirements. Furthermore, comparative evaluations of the trans-thoracic biopsy's cost-effectiveness against alternative procedures or interventions could be compromised, as indirect costs play a significant role in shaping the relative economic attractiveness of these options. While our study contributes valuable insights into the direct costs of the procedure, readers should be mindful of the limitations imposed by the absence of indirect cost analysis. Moreover, the calculated cost of transcutaneous biopsy with scan guidance did not include the cost of patients' day hospitalization or the cost of hospitalization for patients who presented post-TTB complications.

CONCLUSIONS

In conclusion, a precise understanding of the real costs of any medical procedure is essential for making informed decisions in cost-effectiveness analyses. The full cost method is the reference method in analytical accounting, providing a clear and explicit delimitation of the different cost components and can be easily adapted to different types of institutions and practices. This method subdivides costs into direct and indirect costs. In turn, direct costs are divided into variable and fixed components. Variable costs include consumables and wages of personnel involved in the «labor» act. Fixed direct costs are those that do not vary during the study period; they include the costs of purchasing, depreciation, maintenance, and repair of the scanner room equipment. In total, the direct cost of a transcutaneous biopsy with scan guidance, which is the sum of fixed and variable charges, was 310.191 TND. Indirect costs were not included due to the absence of analytical accounting at the hospital

REFERENCES

1. Davidoff AJ, Powe NR. the role of perspective in defining economic measures for the evaluation of medical technology. Int J Technol Assess Health Care. 1996 Mar 10;12(1):9 21.
2. Taheri PA, Butz D, Griffes LC, Morlock DR, Greenfield LJ. Physician impact on the total cost of care. Ann Surg. 2000 Mar;231(3):432 5.
3. Janne D'Othée B, Langdon DR, Bell GK, Bettmann MA. Operating expenses for the diagnosis and treatment of peripheral vascular disease in an academic interventional radiology department: Cost calculations according to a microeconomic method. J Vasc Interv Radiol. 2006 Jan;17(1):85 94.
4. Durand-Zaleski I, Dalla-Palma L, Dixon A, Reiser M, Soimakallio S, Chaix C. Evaluation economique en radiologie. J Radiol. 1998 Jul;79(7):645 50.
5. Roberts RR, Frutos PW, Ciavarella GG, Gussow LM, Mensah EK, Kampe LM, et al. Distribution of variable vs fixed costs of hospital care. JAMA. 1999 Feb;281(7)644.
6. Owonayo O, C TK, Kodjo K, Prénam H, ES KTV, Moustafa M. Coût de la lombalgie et de la lomboradiculalgie communes en consultation rhumatologique à Lomé. Tunis Med. 2017 Mar ;95(3).
7. Janne d'Othée B, Bettmann MA, Pirard S, Zhuang Z, Black W. Etudes de coût-efficacité et coût-utilité en radiologie. J Radiol. 2001 Dec;82:1687 92
8. Detsky AS, Naglie IG. A clinician's guide to cost-effectiveness analysis. Ann Intern Med. 1990 Jul;113(2):147.
9. Le haut conseil pour l'avenir de l'assurance médicale (HCAAM). Les equipements lourds d'imagerie : rapport innovation et système de santé. [en ligne]. Available at URL: <https://www.securite-sociale.fr/files/live/sites/SSFR/files/medias/HCAAM/2015/ ANNEXE/HCAAM-2015-RAPPORT-ANNEXE-LES_EQUIPEMENTS_LOURDS_D-IMAGERIE.pdf>
10. Decree of the Minister of Public Health of June 1st, 2006, establishing the general classification of professional acts of physicians, biologists, dentists, clinical psychologists, midwives, and medical assistants. (Official Journal of June 9th, 2006). Available at URL: http://www.iort.gov.tn/WD120AWP/WD120Awp.exe/CTX_15572-10-VZuEQayVap/AfficheJORT/SYNC_-1842301697
11. Decree of the Ministers of Finance and Public Health of December 19th, 1996, setting the rates for care of paying patients in public health facilities under the Ministry of Public Health. (Official Journal of December 27th, 1996). Available at URL: http://www.santetunisie.rns.tn/fr/presentations/textes-juridiques-et-reglementaires?start=49
12. Decree of the Minister of Finance and the Minister of Public Health of July 7th, 2008, amending the decree of December 19th, 1996,

setting the rates for care of paying patients in public health facilities under the Ministry of Public Health. (Official Journal of July 11th, 2008).Available at URL: https://www.pist.tn/jort/2008/2008F/Jo0562008.pdf

13. National Health Insurance Fund. List of medical and paramedical procedures [Online]. National Health Insurance Fund. 2010. Available at URL: http://www.cnam.nat.tn/doc/upload/RBactes.pdf.
14. Chasseing D: Communication to the Senate Social Affairs Committee. 2016. Available at URL:https://www.apmnews.com/documents/201605111330170. cour_des_comptes_rapport_imagerie_medicale.pdf.
15. The Royal College of Radiologists, British Society of Interventional Radiology. Investing in the interventional radiology workforce: the quality and efficiency case. United Kingdom: BSIR; 2010.