

Cost and Morbidity of Three-Dimensional Laparoscopic Living Donor Nephrectomy in Morocco

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Abstract

Original Research Article

Objective. To describe hospital tariff-based direct medical expenditure and morbidity associated with three-dimensional laparoscopic living donor nephrectomy at a Moroccan university hospital. **Methods.** This retrospective descriptive single centre study included 51 donors operated on between January 2014 and December 2023. All procedures were left transperitoneal laparoscopic nephrectomies using 3D vision. Expenditure was valued using the national professional fee schedule and hospital administrative data. Morbidity was reported using the Clavien–Dindo classification. An exploratory scenario replaced the five hospital days used in the costing schedule with the reported mean length of stay. **Results.** Mean donor age was 49.12 years; 33 donors were women and 18 were men. Mean total and postoperative stays were 6.87 and 3.62 days, respectively. Estimated tariff-based expenditure was 17,714.75 Moroccan dirhams (MAD) per procedure. Dedicated laparoscopic equipment accounted for 10,050 MAD (56.7%). Substituting 6.87 hospital days increased the estimate to 18,088.75 MAD (+2.1%). Reported Clavien–Dindo grade I and II complication rates were 35.29% and 7.84%, respectively, while 56.86% of donors had no complication. No conversion, transfusion, reoperation or intensive care admission was reported. One incisional hernia and two glomerular filtration rate values below 60 mL/min were reported without documented timing. **Conclusion.** This series describes 3D laparoscopic donor nephrectomy in a Moroccan university setting, with dedicated equipment accounting for most tariff-based expenditure. The absence of a comparator, full costing and standardized follow-up precludes conclusions about the incremental economic value of 3D vision or long-term donor safety.

Keywords: Living donor; nephrectomy; laparoscopy; three-dimensional vision; hospital cost; Morocco.

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INTRODUCTION

The development of living donor kidney transplantation entails two requirements: protecting an individual who derives no direct medical benefit from nephrectomy and allocating resources in a way that sustains the programme. In established programmes, the European Association of Urology guidelines favour laparoscopic donor nephrectomy, particularly because of its advantages in postoperative recovery [1]. These recommendations concern the surgical approach and do not, by themselves, establish a clinical or economic benefit specifically attributable to three-dimensional vision.

In Morocco, organ donation, procurement and transplantation are governed by Law No. 16-98 [2]. Beyond this legal framework, the practical conditions governing access to transplantation must be considered.

A survey conducted in seven haemodialysis centres in southern Morocco identified barriers related to patient information and perceptions [3]. Describing expenditure associated with donor nephrectomy may inform one aspect of transplant programme organisation, but does not encompass all barriers to living donation.

Three-dimensional vision has been evaluated in donor series and in comparisons with two-dimensional vision [4,5]. However, applying the economic findings to Morocco requires local data, because device prices, procedure tariffs and hospital stay arrangements differ across healthcare systems. The primary objective of this study was to estimate direct medical expenditure associated with 3D laparoscopic donor nephrectomy, valued using the tariffs applied at Mohammed VI University Hospital in Marrakech. The secondary

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objectives were to describe morbidity and identify the main expenditure categories.

PATIENTS AND METHODS

Study design and setting

This retrospective, descriptive, single-centre study included 51 living donor nephrectomies performed at Mohammed VI University Hospital in Marrakech between January 2014 and December 2023. The local laparoscopic donor nephrectomy programme began in February 2013. The analysis concerned the donor care pathway and did not cover the entire transplantation episode for the recipient. No open surgery, 2D laparoscopy or robotic surgery comparison group was available.

Reporting was structured according to the transparency principles of STROBE applicable to an observational study and the relevant CHEERS 2022 items for the economic component [6,7]. The study provided a tariff-based expenditure description alongside clinical outcomes, without a comparative cost-effectiveness analysis or a calculation of cost per quality-adjusted life-year.

Organisation of donor nephrectomy and clinical variables

All 51 procedures were performed using a left transperitoneal laparoscopic approach with 3D vision. The team comprised four laparoscopic surgeons working in pairs, urology residents providing surgical assistance, and four operating theatre nurses. The characteristics analysed were age, sex, body mass index (BMI), ASA physical status classification and the presence of health coverage. Total hospital stay and postoperative stay were described separately.

Morbidity was reported using the Clavien–Dindo classification [8]. The available results were also reviewed for conversion, transfusion, reoperation and intensive care admission. Incisional hernia and glomerular filtration rate (GFR) values below 60 mL/min were described separately, because their timing and relationship to the complication classification were not documented. No uniform follow-up period could be assigned to the reported events.

Scope and valuation of expenditure

Valuation was based on the national professional fee schedule (NGAP) and information supplied by the hospital billing office. The scope included hospitalisation, preoperative and postoperative laboratory tests, imaging, dedicated laparoscopic equipment, intravenous fluids, medications, other supplies, and surgical and anaesthetic procedures. The hospitalisation tariff was 200 MAD per day, applied to five days in the base estimate.

The primary economic measure was the sum of the ten expenditure categories, expressed in Moroccan dirhams (MAD). This sum constituted a tariff-based estimate per procedure. In the absence of itemised individual invoices, it could not be interpreted as an empirical mean of costs for the 51 donors. Administrative tariffs do not necessarily measure the opportunity cost of the resources used. No separate valuation was available for depreciation and maintenance of the 3D laparoscopic system, staff time, overheads or sterilisation. Some of these resources may have been included in the tariffs, but their contribution could not be determined.

Recipient-specific expenditure, long-term care, transport and donors' loss of income were not quantified. The reference prices and price year were not documented in sufficient detail to allow inflation adjustment or a reproducible international currency conversion. Results were therefore retained in MAD, without monetary adjustment over the 2014–2023 period.

Descriptive analysis and exploratory scenario

Continuous variables were presented as means and, where available, measures of dispersion or ranges. Categorical variables were described using counts and percentages. Expenditure shares were recalculated from the itemised amounts. No comparative testing, multivariable adjustment or imputation of missing data was performed.

The available Clavien–Dindo distribution, reported as rounded percentages, was retained. Counts for grade II and for donors without complications were reconstructed arithmetically using a denominator of 51 and are identified as such in Table 3. For an event explicitly reported in zero of 51 donors, the upper bound of an exact two-sided 95% Clopper–Pearson confidence interval was calculated to illustrate the limited precision of the series.

An exploratory scenario replaced the five hospital days used in the tariff-based estimate with the reported mean total stay of 6.87 days, while keeping the daily tariff of 200 MAD and all other expenditure categories constant. This calculation assessed the impact of the discrepancy on the total. It did not represent a new individual cost measurement or an observed saving.

RESULTS

Donor characteristics and hospital stay

The 51 donors included 33 women (64.7%) and 18 men (35.3%), yielding a male-to-female ratio of 0.55 when rounded to two decimal places. Mean age was 49.12 years, with a range of 20–72 years. Reported mean BMI was 25.8 ± 4.6 kg/m², and seven donors (13.7%) had a BMI above 30 kg/m². All were described as ASA I. Health coverage was reported in 90.2% of cases, under

the schemes listed for the study period: CNSS, CNOPS, RAMED and FAR (Table 1).

Mean total hospital stay was 6.87 ± 2.99 days, with a range of 3–15 days. Nine donors (17.6%) stayed for more than ten days. Mean postoperative stay was 3.62 days. The reasons for prolonged stays and the individual breakdown between preoperative and postoperative days were not detailed.

Distribution of expenditure

The sum of the expenditure categories was 17,714.75 MAD per donor nephrectomy (Table 2). Dedicated laparoscopic equipment accounted for 10,050 MAD, or 56.7% of the total. Surgical procedures accounted for 2,530 MAD (14.3%) and imaging for 2,400 MAD (13.5%). The hospitalisation component was 1,000 MAD (5.6%) for five days.

Laboratory tests accounted for 225 MAD (1.3%). Intravenous fluids, medications, miscellaneous supplies and anaesthetic services together totalled 1,510.75 MAD (8.5%). Combining laparoscopic equipment with the two supplies categories yielded 10,471 MAD, or 59.1% of the total. No measure of between-donor variation in expenditure was available.

In the scenario using 6.87 hospital days, the hospitalisation component increased from 1,000 to 1,374 MAD, and the total estimate reached 18,088.75 MAD. The difference was 374 MAD per procedure, equivalent to 2.1% of the base estimate. Dedicated equipment remained the largest expenditure category, accounting for 55.6% of the recalculated total.

Reported morbidity

The available distribution indicated grade I complications in 35.29%, grade II complications in 7.84%, and no complications in 56.86% of donors (Table 3). The number of donors with grade I complications was 18. The other two percentages corresponded to four and 29 of the 51 donors, respectively. No grade above II appeared in this distribution, for which the observation period was unspecified.

No conversion, transfusion, reoperation or intensive care admission was reported. For each event considered separately, a frequency of 0/51 corresponded to an upper bound of 6.98% for the exact two-sided 95% confidence interval, assuming complete ascertainment. One postoperative incisional hernia was reported, together with two GFR values below 60 mL/min in donors described as older. Follow-up duration, the number of donors actually assessed at the time of these measurements, the method used to calculate GFR and whether it was indexed to body surface area were unavailable. These observations therefore did not allow estimation of the incidence of persistent kidney impairment.

DISCUSSION

Economic interpretation of the findings

This study describes the expenditure categories associated with 51 3D laparoscopic donor nephrectomies at a Moroccan university hospital. Its main finding is the predominance of dedicated equipment in the tariff-based valuation. This expenditure structure provides a practical starting point for examining procurement and programme financing. However, the amount of 17,714.75 MAD represents neither the full cost of kidney transplantation nor the donor's out-of-pocket expenditure.

Interpretation requires a distinction between tariffs, billed expenditure and economic costs. A procedure tariff may incorporate some resources, omit others or fail to reflect their actual consumption. This distinction is particularly important for equipment shared across several activities. Without acquisition costs, service life, maintenance costs and the activity volume attributable to donor nephrectomy, the potential additional cost of 3D vision cannot be isolated. The transparency requirements concerning perspective, price year and resources valued, reiterated in CHEERS 2022, are directly relevant to an extension of this analysis [7].

International comparisons inform methodology rather than support a ranking of centres by cost. In the French multicentre DOVIREIN study, Achit *et al.* used microcosting in 264 donors across 20 centres. Disposable instruments cost EUR 611.6 for standard laparoscopy, but personnel expenditure constituted a major component of the total [9]. This scope differs from the summation of Moroccan hospital tariffs. Differences between published amounts therefore do not demonstrate differences in efficiency.

The Dutch randomised study by Klop *et al.* distinguished a healthcare system perspective from a societal perspective that included return to work [10]. The resulting totals extended beyond operative expenditure alone and depended on the scope adopted. The earlier study by Berney *et al.* had already shown that the balance between consumable costs and length of stay affected the comparison between open and laparoscopic approaches [11]. These studies do not justify directly applying their prices to Marrakech, given their different periods, currencies and methods.

Dedicated equipment and organisation of the hospital stay

The contribution of dedicated equipment suggests that further analysis should begin with a precise inventory of the devices used, their quantities and their purchase prices. Equipment and consumables must be distinguished, particularly to avoid charging the full cost of reusable equipment to each donor or, conversely, overlooking its maintenance. A coordinated procurement

policy could be evaluated, but its impact cannot be quantified from these findings.

The mean stay of 6.87 days exceeded the five days used in the costing schedule. The scenario presented shows that this discrepancy changes the tariff-based total only modestly, because hospitalisation accounts for a relatively small share. This should not, however, be interpreted as indicating that bed availability or staff time has little economic value. A shorter stay would be beneficial only if it preserved donor safety and did not shift expenditure to care after discharge that was not included in the analysis.

The postoperative stay of 3.62 days must also be distinguished from the total stay. Admission in advance of surgery to complete the assessment could contribute to the difference, but this hypothesis was not evaluated. A subsequent study should document reasons for admission, the date on which assessment was completed, and the causes of stays exceeding ten days before proposing changes to the care pathway.

Clinical outcomes and the specific contribution of 3D vision

The reported absence of conversion, transfusion and reoperation is encouraging for the local programme. However, it does not exclude rare events, as illustrated by the upper confidence bound of nearly 7% for an observed frequency of zero among 51 donors. The proportion of minor complications must also be interpreted in light of the types of events recorded and the surveillance period. Without this information, crude comparisons of rates between centres would be unreliable.

In a prospective series of 110 3D donor nephrectomies, Kumar *et al.* reported no conversions and described donor and graft outcomes during follow-up [4]. Rysmakhanov *et al.* retrospectively compared 19 hand-assisted 3D procedures with 19 2D procedures. They observed differences in some perioperative

parameters, without a significant difference in postoperative renal function between groups [5]. These findings support further evaluation of 3D vision, but the sample sizes and surgical approaches limit their applicability to our series.

Our study included no comparator that would allow the outcomes to be attributed to 3D vision. Operative time, warm ischaemia time, blood loss and recipient outcomes were unavailable for analysis. It therefore remains impossible to determine whether 3D vision changed resource use or morbidity compared with 2D vision. Similarly, the photographic documentation cannot establish superior cosmetic outcomes in the absence of standardised measurement and donor assessment.

Donor follow-up and the Moroccan context

One incisional hernia and two GFR values below 60 mL/min require longitudinal description. Without baseline values, a measurement method and repeat assessment over time, a single value cannot establish chronic kidney disease after donation. KDIGO guidelines recommend regular follow-up, at least annually, including blood pressure, kidney function and albuminuria [12]. Funding for this surveillance should be studied separately from the donor nephrectomy admission.

The health coverage reported in 90.2% of donors provides no information on actual reimbursement or household expenditure. Assessing the accessibility of living donation in Morocco would also require measurement of travel expenses and time off work, as well as access to follow-up outside the university hospital. The survey by Dakhama *et al.* in southern Morocco also highlights the role of information and risk perceptions in acceptance of transplantation [3]. Economic findings should therefore be accompanied by understandable information on benefits for recipients and risks for donors.

Table 1: Donor characteristics and length of hospital stay

Characteristic	Value
Donors	51
Study period	January 2014 to December 2023
Mean age, years	49.12 (range 20–72)
Women	33 (64.7%)
Men	18 (35.3%)
BMI, kg/m ²	25.8 ± 4.6
BMI > 30 kg/m ²	7 (13.7%)
Reported ASA class	I in all 51 donors
Health coverage	90.2%
Side of nephrectomy	Left in all 51 cases
Total hospital stay, days	6.87 ± 2.99 (range 3–15)
Total stay > 10 days	9 (17.6%)
Mean postoperative stay, days	3.62

Data are presented as counts (percentages), unless otherwise specified. Values following the $\pm$ symbol reproduce the reported measure of dispersion; its exact nature must be confirmed before submission. Percentages associated with explicit counts were recalculated using 51 donors as the denominator.

BMI: body mass index. **ASA:** American Society of Anesthesiologists. Health coverage is reported according to the schemes in place during the study period and does not measure actual reimbursement.

Table 2: Tariff-based estimate of expenditure per donor nephrectomy

Category	Valuation basis	Amount MAD	Share %
Hospitalisation	200 MAD/day $\times$ 5 days	1,000.00	5.6
Preoperative and postoperative laboratory tests	Total amount	225.00	1.3
Intravenous fluids	Total amount	275.00	1.6
Medications	Analgesics, anticoagulants, antibiotics	282.00	1.6
Imaging	Chest radiography, abdominal ultrasound, CT angiography	2,400.00	13.5
Dedicated laparoscopic equipment	Composition not detailed	10,050.00	56.7
Disposable supplies	Category reported separately	280.00	1.6
Sutures, gloves, blades, catheters and drains	Total amount	141.00	0.8
Surgical procedure	Reported fee code K100	2,530.00	14.3
Anaesthesia	Medications and procedure	531.75	3.0
Total	Base estimate	17,714.75	100.0

MAD: Moroccan dirham. Valuation is based on the national professional fee schedule (NGAP) and hospital billing information. Shares are rounded to one decimal place and may not add up to exactly 100%. This estimate is not a documented mean of 51 individual invoices.

Exploratory scenario with all other expenditure categories held constant: 6.87 days $\times$ 200 MAD = 1,374 MAD for hospitalisation; recalculated total of 18,088.75 MAD (+374 MAD; +2.1%).

Table 3: Reported morbidity and clinical events

Category or event	Count	Proportion or details
No complications	29*	56.86%†
Clavien–Dindo I	18	35.29%†
Clavien–Dindo II	4*	7.84%†
Conversion	0	0%
Transfusion	0	0%
Reoperation	0	0%
Intensive care admission	0	0%
Postoperative incisional hernia	1	Timing unspecified
GFR < 60 mL/min	2	Follow-up duration and denominator unspecified

* Counts reconstructed from rounded percentages and the total of 51 donors; to be confirmed against individual data. The count of 18 donors with grade I complications is explicitly reported.

† Percentages reproduced as reported; they add up to 99.99% because of rounding. The observation window for the classification is unspecified. Incisional hernia and GFR abnormalities should not be added to these categories, because overlap cannot be excluded.

GFR: glomerular filtration rate. For each event with zero occurrences considered separately, 0/51 corresponds to an exact two-sided 95% confidence interval of 0–6.98%, assuming complete ascertainment. Mortality, readmissions and completeness of follow-up are not documented.

Limitations and future research

The retrospective, single-centre, descriptive design limits the generalisability of the findings. The exclusive selection of left kidneys, the small sample size and the absence of information on donors assessed but not operated on prevent a full assessment of selection bias. Changes in activity, practice and prices over ten years cannot be analysed using the available aggregate data.

The main economic limitation is the absence of individual invoices and full costing. The price year, the detailed composition of dedicated equipment and the length of stay used for valuation must be documented to make the estimate reproducible. Clinically, the complication ascertainment window, loss to follow-up and longitudinal renal function remain insufficiently characterised. These limitations do not negate the descriptive value of the experience, but they preclude demonstration of cost-effectiveness or long-term safety.

A prospective multicentre Moroccan study could record, for each donor, the quantities of resources consumed, purchase prices and clinical outcomes at predefined time points. Comparison with 2D laparoscopy, where consistent with participating centres' practices, would allow evaluation of the contribution of 3D vision. Assessing follow-up and donor-borne expenditure would extend the evaluation beyond the hospital episode alone.

CONCLUSION

Among these 51 donors operated on at Mohammed VI University Hospital in Marrakech, the tariff-based estimate for 3D laparoscopic donor nephrectomy was 17,714.75 MAD, with dedicated equipment accounting for 56.7%. Replacing the five days used in the valuation with the reported mean stay increased the estimate to 18,088.75 MAD. No conversion, transfusion, reoperation or intensive care admission was reported. These data provide a local descriptive basis for a more comprehensive cost analysis. Individual documentation of resources, complications and follow-up is required before an economic or clinical advantage specifically attributable to 3D vision can be established.

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