Cost-benefit comparison of hemodialysis access creation in a developing country and North American centres

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OBJECTIVE: It has been suggested that vascular access operations should only be performed in high-volume centres to ensure good outcomes. Vascular access operations have been routinely performed in the Cayman Islands since 2005. However, with an estimated population of 45,000 persons, only a small number of patients require vascular access in any given interval. A cost-benefit analysis of this practice was performed.

METHODS: All patients who had vascular access operations over four years were retrospectively identified. Two groups were defined – the local group, who had operations performed by surgeons in the Cayman Islands, and the offshore group, who were transferred off the island and had operations overseas. Cumulative cost, morbidity, patency and failure rates were compared. Significance was considered present with a two-tailed $P \leq 0.05$.

The demand for vascular access for hemodialysis is rising because the incidence of end-stage renal disease (ESRD) is increasing throughout the western world (1). Although the prevalence of ESRD in most Caribbean countries is comparable with that in developed nations (2), the absolute number of patients with ESRD remains small.

It has been suggested that vascular access operations should only be performed in high-volume centres to minimize morbidity and maximize patency (3). Therefore, many Caribbean countries transfer patients overseas to developed countries to establish vascular access. This comes at a high cost that many Caribbean countries may find economically difficult to sustain. Faced with this dilemma, many surgeons in these countries embark on access creation (4).

The situation in the Cayman Islands is typical. With the prevalence of ESRD reported as 0.975 cases per 1000 people (5), and an estimated population of 45,000 (6), only a small number of patients require vascular access operations in any given interval.

The Health Service Authority (HSA) of the Cayman Islands manages the only facilities nationwide that provide dialysis services to patients with ESRD (5). Before 2005, all patients were transferred to centres in the United States to

RESULTS: There were 14 patients in the local group and 22 in the offshore group. The mean cost of access creation was 6.9 times greater in the offshore group (US\$26,883.36 versus US\$3,913.33; $P < 0.001$). The likelihood of the use of arteriovenous grafts was significantly greater in the offshore group ($P = 0.04$). When therapeutic outcomes were compared, there were no differences in primary or secondary failure, primary or secondary patency, or overall access-specific morbidity.

CONCLUSIONS: In the present setting, vascular access creation exceeded all the goals set by the National Kidney Foundation Kidney Disease Outcomes Quality Initiative and the Fistula First Breakthrough Initiative. Compared with overseas centres, this is being achieved at a significantly lower cost, with a greater likelihood of native fistula use and similar therapeutic outcomes.

Key Words: Arteriovenous fistula; Arteriovenous graft; Cost-benefit analysis; End-stage renal disease; Hemodialysis; Vascular access

establish vascular access because this service was unavailable locally. In 2005, the HSA established a vascular access service to facilitate access creation by local surgeons (7). Inception of the local vascular access service came as a cost-saving measure for the Cayman Islands, despite suggestions that access creation should only be performed in high-volume centres (3). We performed a cost-benefit analysis of this practice to determine whether it is feasible to continue to provide patients with ESRD in the Cayman Islands with access creation locally.

METHODS

Before 2005, all patients with ESRD who required hemodialysis were transferred to centres in the United States to establish vascular access because there was no locally available vascular surgeon. Once requested by a managing physician, clerical staff arranged patient transfers to hospitals affiliated with the HSA within the United States. Thereafter, clinical staff at the receiving hospital made all necessary clinical management decisions independent of input from the referring physicians and/or institutions. There was no information available from these centres on the results of Doppler ultrasound mapping, operative details, or any insight into their selection of the type and/or location of access created.

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In 2005, the HSA established a vascular access service to facilitate access creation by local surgeons (7). This service is supported by dedicated nephrology services, immediate access to an on-site dialysis unit, specialized operative equipment and a full range of auxiliary services, including Doppler ultrasound vascular mapping and intraoperative fluoroscopy.

After inception of the vascular access service, all access operations were performed on the island. Patients were only transferred overseas if the vascular surgeon was not physically available to create the access in a timely fashion; necessary operative equipment such as vascular grafts and/or appropriate catheters were not in stock to facilitate the proposed operation; or the patient required emergent overseas transfer for a concomitant medical condition and also required access creation. Otherwise, all patients who required access operations were treated locally by the vascular access service. The local vascular access service did not engage in any sort of screening or triage to identify patients to be referred overseas for access creation.

All patients were evaluated preoperatively by physical assessment and investigated with vascular mapping by Doppler ultrasound. If there were no suitable vessels for native vascular access creation, the patient was scheduled for insertion of an arteriovenous graft (AVG). This decision was made by the vascular surgeon and was based on clinical and Doppler ultrasound examination, and the number, type and location of previous accesses.

Ethical approval from the HSA was secured to collect and analyze data for the present study. A database of all patients with ESRD in the Cayman Islands who required maintenance hemodialysis was created. The patients were identified by retrospective analysis of the patient registers from all dialysis units in the Cayman Islands between January 1, 2005, and January 1, 2009.

From this database, patients who had new dialysis accesses created within the study period were identified and their hospital records were accessed for detailed analysis. Patients were excluded from analysis if their hospital records were unavailable or incomplete. Patients who had additional intraoperative procedures were included in the analysis once they had new dialysis access creation at the same sitting.

Two patient groups were defined – patients who had surgical accesses created by the Cayman Islands vascular access service (local group), and patients who were transferred off the island and had accesses created by overseas vascular surgeons (off-shore group).

The final cumulative cost accrued by each patient in the local group was attained by accessing hospital financial records. The cumulative hospital costs associated with local access creation were analyzed, including operative fees, physician fees, cost of investigations, cost of supplies and interim dialysis sessions.

The final cumulative costs accrued by offshore patients were supplied by local health insurance companies. The insurance companies provided the total claim amount for access creation. They declined to provide any information on specific centres at which treatment was provided, claim details, current procedural terminology codes, reimbursement rates or itemized invoices for detailed analysis. The figure provided was not inclusive of transportation costs. The individual patient deductibles were not subtracted from the cumulative costs supplied.

The clinical data extracted from hospital records included patient demographics, details of previous accesses, location and type of new access, operative details, morbidity, access patency, access failure and details of repeat interventions.

Standardized definitions of access-specific outcome measures were used in the present study (8). An arteriovenous fistula (AVF) was defined as a direct anastomosis between an autogenous artery and vein. Once the surgeon interposed exogenous material between the native vessels, the access was considered to be an AVG.

An AVF or AVG was considered to be functional if it was able to support the patient's dialysis prescription by providing a blood flow of 300 mL/min or greater during dialysis sessions (8). An AVF or AVG that could not provide a blood flow of 300 mL/min or greater for adequate dialysis was considered to be a failed access (8).

Primary failure was defined as an access that could not be cannulated or could not maintain a blood flow of 300 mL/min or greater after allowing six weeks for maturation (8). Secondary failure was defined as failure of an access that was previously used for successful dialysis (8).

Primary patency was defined as the interval between access placement and the first endovascular or surgical intervention to address access failure (8). Secondary patency was the interval between access placement and abandonment, including any period after surgical or endovascular interventions (8).

The data recorded during the study period were entered into a Microsoft Excel worksheet (Microsoft Corp, USA) and analyzed using SPSS version 12.0 (SPSS Inc, USA). Comparisons were made between the groups using Fisher's exact tests and χ^2 statistics. Significance was considered to be present with a two-tailed $P \leq 0.05$.

RESULTS

During the study period, 67 operations were performed in 57 patients to create vascular access. Complete clinical and/or financial data were unavailable for 31 patients and they were excluded from further analysis.

Of the 36 cases analyzed, 14 were in the local access group. This group was composed of 10 men with a mean ($\pm$ SD) age of 59.1 ± 13.7 years (range 40 to 79 years, median 63 years and mode 79 years) and four women with a mean age of 49.7 ± 13.4 years (range 35 to 67 years, median 51 years and mode 51 years).

There were 22 patients in the offshore access group. Their procedures were all performed at centres within the United States. This group consisted of 12 men with a mean age of 62.3 ± 9.9 years (range 43 to 79 years, median 63.5 years and mode 60.9 years) and 10 women with a mean age of 49.9 ± 15.4 years (range 22 to 75 years, median 51 years and mode 61 years).

Table 1 compares the therapeutic outcomes of vascular access creation in the local and offshore groups. There were no significant differences in access-specific complications, primary or secondary failure, or primary or secondary patency.

However, there were notable differences in the type of access created between the groups (Table 1). The likelihood of prosthetic graft use for vascular access was significantly greater in the offshore group than in the local group (68.2% versus 28.6%, respectively, OR 1.9 versus 0.36; $P=0.04$).

When incident dialysis patients (patients who had never undergone hemodialysis) were evaluated, a significantly greater

TABLE 1
Comparison of the outcomes of vascular access surgery at local and offshore centres

	Local	Offshore	P
Cases, n	14	22	–
Native AV fistula, n (%)	10 (71.4)	7 (31.8)	0.04
Prosthetic AV graft, n (%)	4 (28.6)	15 (68.2)	0.04
Dialysis cases			
Prevalent dialysis cases, n	8	17	–
AV fistula, n (%)	4 (50)	6 (35.3)	
AV graft, n (%)	4 (50)	11 (64.7)	
Incident dialysis cases, n	6	5	–
AV fistula, n (%)	6 (100)	1 (20)	0.015
AV graft, n (%)	0 (0)	4 (80)	0
Outcome measures			
Access failures, n (%)			
Primary failure	0 (0)	1 (4.6)	–
2° failure	6 (42.9)	12 (54.5)	0.41
Duration of patency, days			
Primary patency			
Mean ± SD	450.71±290.45	393.18±367.14	0.62
Range	123–1088	30–1360	
Median	444	252	
2° patency			
Mean ± SD	482.40±225.97	555.70±422.20	1.0
Range	200–790	90–1367	
Median	458	384.50	
Interquartile range (average of the first and third quartiles)	416	656	
Interventions for 2° patency, n (%)	2 (33.3)	5 (41.7)	0.22
Ligation of tributaries, n	1	2	
Operative thrombectomy, n	1	2	
Percutaneous stenting, n	0	1	
Complications, n (%)			
Overall morbidity	7 (50)	16 (72.7)	0.27
Surgical site infection	2 (14.3)	4 (18.2)	0.76
Bleeding	0 (0)	1 (4.6)	0.42
Steal syndrome	0 (0)	1 (4.6)	0.42
Access thrombosis	5 (35.7)	9 (40.9)	0.75
Aneurysm	0 (0)	1 (4.6)	0.42
Mortality	0 (0)	0 (0)	–

2° Secondary; AV Arteriovenous

rate of native fistula use for vascular access was seen in the local group than in the offshore group (100% versus 20%, respectively; $P=0.015$). A similar trend was noted in prevalent dialysis patients, with AVF more commonly used in the local group (Table 1).

There was a significant difference in cost for access creation between the groups. There was no cost subsidization for vascular access creation in the Cayman Islands. The mean cost of access creation in the local group was US\$3,913.33±361.64 (range US\$3,224.39 to US\$4,493.40, median US\$3,862.61 and mode US\$3,843.90). The mean cost in the offshore group was 6.9 times greater, at a mean cost of US\$26,883.36±9,331.94 (range US\$14,304.00 to US\$47,091.00, median US\$25,000.00 and mode US\$25,000.00).

When the distribution of the figures was analyzed, there was a wide range of costs in the offshore group (Figure 1). After exclusion of the upper end outliers in the offshore group (Figure 2), there was still a significantly greater cost for

Figure 1) Overall cost of vascular access operations at local and offshore centres. Std Dev Standard deviation

Figure 2) Distribution of cost for vascular access at local and offshore centres

overseas access creation ($P<0.001$), with a mean cost of US\$25,031.00±7,497.39 (range US\$14,304.00 to US\$40,000.00, median US\$25,000.00 and mode US\$25,000.00).

DISCUSSION

The prevalence of ESRD (0.975 cases per 1000 people) in the Cayman Islands (5) is similar to that in other developing countries (1,2). The majority of patients in this setting are dependent on adequate vascular access for successful maintenance hemodialysis (7).

Based on a wealth of existing data, there is now a consensus that the ideal form of vascular access for hemodialysis is an AVF (9-13) because it carries lower complication rates and a longer duration of event-free patency than catheter access (9-11,14-17) and AVGs (13,15,18-22). The United States National Kidney Foundation (NKF) published the Dialysis Outcomes Quality Initiative Vascular Access Guidelines (9) in 1997 in an attempt to encourage increased utility of AVFs. The updated Kidney Disease Outcome Quality Initiative (KDOQI) guidelines (10) were published in 2006 with

recommendations for hemodialysis by AVF in at least 40% of prevalent patients and in at least 50% of incident patients.

The United States-based Centers for Medicare & Medicaid Services (CMS) supported these guidelines when it launched the Fistula First Breakthrough Initiative (www.fistulafirst.org) in 2005 that adopted the KDOQI recommendations. The CMS also set stretch goals to increase the utility of AVFs in the United States by 2010 (11,12). The current goal is to have AVFs placed in at least one-half of all new hemodialysis patients and to have a minimum of 66% of all existing patients who continue dialysis to use a fistula (12).

Evaluation of local practice revealed that an AVF was created as a vascular access in 71% of all cases, 50% of prevalent cases and 100% of incident dialysis cases. Therefore, the local vascular access service was performing vascular access operations effectively while exceeding all the goals outlined in the CMS and NKF KDOQI recommendations. However, when our patients were sent to offshore centres, they had AVFs created as a vascular access in 32% of all cases, 35% of prevalent cases and 20% of incident dialysis cases. Neither of these figures met the recommended standards in the CMS or NKF KDOQI guidelines (9-12). This is similar to the practice patterns discovered in the United States through Dialysis Outcomes and Practice Patterns Study (DOPPS) reports (22-24).

Although the small patient numbers limit the statistical analysis in the present report, there was no demonstrable difference in morbidity, mortality, access failure or duration of patency between the local and offshore groups. However, there was a statistically significant difference in the cost to have vascular access established at offshore centres. The mean cost of access creation was 6.9 times greater at offshore centres (US\$26,883.36 versus US\$3,913.33), and this was exclusive of transportation costs.

When cost distribution was analyzed, it was noted that the local group figures were clustered in a small range from US\$3,224.39 to US\$4,493.40 (Figure 1). However, there was a wide range of figures in the offshore group, ranging from US\$14,304.00 to US\$47,091.00. It was notable that the most expensive access created in the local group was three times cheaper than the least expensive access created in the offshore group (US\$4,493.40 versus US\$14,304.00; $P < 0.001$) (Figure 2).

Based on the assumption that some patients in the offshore group may have had difficult operations or additional procedures, we deliberately excluded the upper-end outliers in the offshore group and repeated the cost analysis. Even after exclusion of the upper-end outliers, there was still a significantly greater mean cost for offshore access creation (US\$25,031.00 versus US\$3,913.33; $P < 0.001$).

These figures do not include the cost of transportation to overseas centres. Although there are carrier-related and seasonal variabilities, the average cost of commercial travel to the United States exceeds 10% of the mean cost for AVF creation locally.

CONCLUSION

In this setting, vascular access creation exceeds all the goals set by the NKF KDOQI and the Fistula First Breakthrough Initiative. Compared with overseas centres, this is being achieved at a significantly lower cost, with a greater likelihood of native fistula use and similar therapeutic outcomes.

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