Review of Efforts to Decrease Costly Leg Wound Complications in the Medicare Population Following Coronary Revascularization

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ABSTRACT

Background: Current trends show that patients referred for coronary artery bypass grafting (CABG) are significantly older, sicker, and at higher risk for complications than ever before. Eliminating leg wound complications would significantly benefit these patients and reduce the consumption of health care time and dollars. Endoscopic vein harvesting (EVH) decreases the risk of wound complications in patients following CABG and may decrease costly long-term woundrelated problems.

Methods: In this retrospective study, the cases of 1909 Medicare patients who had undergone EVH or open vein harvesting (OVH) for CABG were reviewed. The risk factors of these patients were examined and compared with those of 1485 non-Medicare patients. Readmissions, home health care costs, and office lengths of service were reviewed and analyzed.

Results: The results of univariate analyses of the Medicare versus non-Medicare populations indicated significant differences for peripheral vascular disease (25.4% versus 17.2%; P < .0001), renal failure (6.0% versus 2.8%; P < .0001), hypertension (75.4% versus 71.5%; P = .011), female sex (31.1% versus 22.4%; P < .0001), mean age (69.8 years versus 57.1 years; P < .0001), and mortality risk (4.6% versus 2.2%; P < .0001). The wound rates in the Medicare group were 1.1% for EVH (n = 741) versus 2.8% for OVH (n = 1168), and this difference was significant (P = .0163) despite a higher frequency of morbid obesity in the EVH population (P < .0001). No significant differences were found in readmission frequency, home health care costs, or office length of service.

Conclusion: EVH benefits Medicare patients. Although this study is the largest to date to use disposable instruments, there is a lack of statistical power in the analysis of cost comparisons due to the small sample size of wound complications. However, there appears to be a general trend toward a lower treatment cost per patient and less resource use with EVH.

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Current trends show that patients referred for coronary artery bypass grafting (CABG) are significantly older, sicker, and at higher risk than ever before [Ferguson 2002]. Many of the risk factors that contribute to mortality also increase the possibility of a leg wound morbidity following CABG. Leg wounds following harvesting of the greater saphenous vein and the subsequent problems with healing following CABG have been reported over the years, with a frequency ranging from 2% to 24% [Goldsborough 1999]. Leg wounds following vein harvest range from superficial to major, and proper medical treatment, such as dressing changes, splitthickness skin grafts, fasciotomies, and amputations, is necessary for wound healing to occur [Paletta 2000]. The initial documentation of these results were from cases involving open vein harvest (OVH) through one continuous incision or multiple bridged incisions. Many patients require readmission for various reasons, including intravenous antibiotic administration, dressing changes, debridements, and possible costly reconstructive or vascular surgery. Leg wound complications consequently increase the amount of time required of surgeons, clinicians, and office personnel in the care of the patient. Care must be provided until the wound is healed or until the patient is turned over to home health services for additional wound treatment. This article attempts to closely examine in the Medicare population the actual costs of a leg wound with regard to readmission costs and subsequent home health care costs.

INTRODUCTION

In the past few years, data have supported the view that endoscopic vein harvesting (EVH) provides an improved technique that results in fewer wound complications [Allen 1998, Allen 2000, Marty 2000]. This difference is noted even in patients with more risk factors for leg wound complications [Carpino 2000]. EVH not only enables a reduction in wound complications but also maintains the quality of the conduit, because several articles have shown no difference in the overall integrity of the vein following harvesting with this technique [Meyer 2000, Alrawi 2001, Lancey 2001]. EVH has demonstrated a greater overall level of patient satisfaction with earlier ambulation, a reduced overall length of stay, and less overall care required for the patients by nursing personnel during hospitalization and by



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Endoscopic vein harvesting with the CardioVations Clearglide system.

family members after patient discharge. This outcome is attributed to the use of a small incision versus a long incision with a known previously described morbidity [Morris 1998, Patel 2001, Kiaii 2002].

The negative aspects of performing EVH have primarily been the perceived increased initial cost and the longer operating room times resulting from a much more labor-intensive procedure. Several articles have shown no statistically significant differences in mean harvesting time or in overall operating room times when the procedure is carried out by experienced clinicians and once the learning curve has been overcome [Patel 2001, Brandt 2002].

METHODS

The study retrospectively reviewed the cases of 1909 Medicare and 1485 non-Medicare patients who had undergone vein harvesting for CABG between May 17, 1999 (the start of our EVH experience), and December 31, 2001. This study specifically looked at the differences in the risks associated with Medicare and non-Medicare patients with respect to leg wounds and their associated costs. All patient data including insurance categories were collected at the time of discharge with software that conforms to the national database of the Society of Thoracic Surgeons (STS).

The greater saphenous vein was harvested either by the traditional OVH technique with or without bridging or by EVH with the CardioVations/Ethicon (Somerville, NJ, USA) vein-harvesting system (Figure). Initially, EVH was performed by 2 physician assistants under the supervision of 2 surgeons in our 7-surgeon, 5-hospital practice. EVH has steadily gained acceptance by all our surgeons and is now being performed by the remaining staff as they learn the procedure. The EVH procedure included making an incision 2 to 4 cm below the knee with an occasional smaller second incision usually located mid thigh. Distal and proximal ligation was achieved with an Endoloop (Ethicon) or

bipolar energy, which results in a minimal number of incisions. Incisions in the lower leg or groin regions were avoided, because these areas are noted for their increased risk of infection [Thomas 1999]. All patients received 1 g cefazolin and an additional 1 g after cardiopulmonary bypass was discontinued. Patients who were allergic to penicillin received 1 g vancomycin hydrochloride (Vancocin) preoperatively. Antibiotic therapy was continued for an additional 48 hours postoperatively. All patients received a povidoneiodine (Betadine) scrub and preparatory solutions before skin incision. Wound closure for both techniques included thorough irrigation with antibiotic solution (cefazolin 1g or bacitracin 50,000 U/L), closure in layers with monofilament suture, and skin closure with either monofilament suture or skin clips. Wound closure in the OVH group occurred either before or after cardiopulmonary bypass was discontinued. All EVH wounds were closed at the time of patient removal from cardiopulmonary bypass and the administration of protamine. Drains were rarely used.

Complications from the time of surgery to the release of service (usually at the 6-week follow-up) were noted and recorded in office charts and in the STS database. A wound complication was recorded if the incision site required any follow-up attention in the form of dressing changes or more aggressive therapy, regardless of culture results such as fat necrosis. All patients specifically recorded for readmission had an admitting diagnosis of postoperative infection resulting from vein harvest.

The observed categories of patients were compared with respect to sex and the presence of diabetes mellitus, peripheral vascular disease, morbid obesity, renal failure, or hypertension. Inclusion of these risk factors met criteria outlined by STS database participation. These conditions are known risk factors for leg wounds in addition to those of the length and location of the incision site [Gandhi 1994, Allen 2000, Thomas 1999]. The statistical significance of comparisons between groups were determined by means of chi-square, Fisher exact, and Student t tests with R software, version 1.4.1 [Ihaka 1996]. A P value $\leq .05$ was used to determine statistical significance (ie, rejection of the null hypothesis). Cost data in actual dollar figures were collected from the billing departments by specifically reviewing the UB-92 billing forms from the 5 area hospitals at which our group practices. Any outlier was confirmed by a review of the medical record and a discussion with the billing department and clinical care coordinator. Home health data were obtained by phone conversations with the company administrators to confirm the actual number of visits required until the patient was released by the home health company.

RESULTS

There were no statistically significant differences in the overall leg wound complication incidence between the 1909 Medicare patients and the 1485 non-Medicare patients with OVH and EVH cases combined (2.2% versus 1.5%, respectively; not significant) (Table 1). Differences between these populations for the various risk factors showed statistically

Table 1. Leg Wound Complication Rates*

		Percent	Р
Overall, OVH/EVH	Medicare (n = 1909)	2.2	NIC
combined ($N = 3394$)	Non-Medicare (n = 1485)	1.5	142
Medicare only (n = 1909)	OVH (n = 1168)	2.8	01/
	EVH (n = 741)	1.1	.016
Non-Medicare (n = 1485)	OVH (n = 936)	2.2	004
	EVH (n = 549)	0.4	.004

*OVH indicates open vein harvesting; EVH, endoscopic vein harvesting.

higher percentages in the Medicare group for peripheral vascular disease (P < .0001), renal failure (P < .0001), hypertension (P = .011), and female sex (P < .0001). Only morbid obesity (P = .003) occurred at a statistically higher frequency in the non-Medicare group; this result correlates with the previously noted higher incidence of morbid obesity among younger age groups [Lyznicki 2001] (Table 2). The percent risk of mortality as calculated by the STS algorithm found a significant difference between the Medicare population (4.6%) and the non-Medicare population (2.2%; P < .0001). Age data were also analyzed to verify the patient populations and proper coding. The mean age of the Medicare group was 69.8 years, and the mean age of the non-Medicare group was 57.1 years (P < .0001). Of the 1909 Medicare patients, 1168 patients underwent OVH, and 741 patients were treated with the EVH method. As indicated in Table 3, the only risk factor to show a statistically significant difference was the incidence of morbidly obese patients in the EVH and OVH populations (17.8% and 10.8%, respectively; P <.0001). This difference was probably due to a selection process at the time of surgery secondary to body habitus. Despite being a patient population at a higher risk for infection, the EVH group had a lower rate of wound complications than the OVH group (1.1% versus 2.8%; P = .0163) (Table 1).

Table 2. Patient Characteristics and Risk Factors of Medicare and Non-Medicare Patients*

	Medicare Patients (n = 1909)	Non-Medicare Patients (n = 1485)	Р
Diabetes mellitus, %	32.0	32.5	NS
Morbid obesity, %	13.6	17.3	.003
Peripheral vascular disease, %	25.4	17.2	<.0001
Renal failure, %	6.0	2.8	<.0001
Hypertension, %	75.4	71.5	.011
Female sex, %	31.1	22.4	<.0001
Nonelective surgery, %	36.2	37.6	NS
Age (mean), y	69.8	57.1	<.0001
No. of distals (mean)	3.6	3.5	NS
Length of stay (mean), d	6.7	6.5	NS
Mortality risk, %	4.62	2.25	<.0001

*NS indicates not significant.

Table 4 notes the readmission costs for both Medicare OVH and Medicare EVH procedures. Analyzed were 1168 OVH Medicare patients with 33 wounds total, which required a total of 10 readmissions for further wound treatment at a total cost of \$152,421 or an average cost of \$15,242 per patient (median cost, \$5743). The 741 EVH Medicare patients had 4 readmissions with a total cost of \$22,177 or an average cost of \$5544 per patient (median cost, \$4849). The OVH group included one notable outlier at \$75,442, and this cost figure was verified via a detailed chart review to ensure that the costs incurred were secondary to the wound infection. Because of the small sample sizes involved and the highly right-skewed nature of the cost data, none of these differences were statistically significant. Attempts were made to see if mathematical transformations (ie, log[cost]), Wilcoxon/ Mann-Whitney nonparametric rank tests, and outlier trimming of the cost data would result in enhancing the power of the comparison. However, these alternative analyses yielded no statistically significant outcomes.

Home health care costs were reviewed next (Table 5). There were 556 visits for wound care among the 15 patients in the OVH group. Typically, the home health agency notifies the physician when it feels it is appropriate to discontinue therapy because of the healing of the wound. None of the home health care organizations would disclose the actual costs billed to the patient. The quoted estimated price per visit was \$100, giving the OVH group an approximate total cost of \$55,600. The average number of visits in this group was 37 per patient. Of the 4 patients in the EVH group who required home health care, the visits totaled 123 (\$12,300) for an average of 31 visits per patient. Next, we reviewed the actual number of days of service to the patient from the date of surgery until the final office visit (Table 6). This review was done to determine the effect on office personnel, supply costs, clinician time, and surgeon time required for lengthy wound treatment. The Medicare OVH wounds required 2760 days for an average of 89.0 days per patient until

Table 3. Characteristics of Medicare Patients Only: Open Vein Harvesting and Endoscopic Vein Harvesting Subgroups*

	OVH (n = 1168)	EVH (n = 741)	Р
Diabetes mellitus, %	31.7	32.5	NS
Morbid obesity, %	10.8	17.8	<.0001
Peripheral vascular disease, %	24.3	27.0	NS
Renal failure, %	5.2	7.3	NS
Hypertension, %	74.5	76.9	NS
Female sex, %	31.3	31.0	NS
Nonelective surgery, %	36.5	35.6	NS
Age (mean), y	69.7	70.1	NS
No. of distals (mean)	3.5	3.7	NS
Length of stay (mean), d	6.7	6.5	NS
Mortality risk, %	4.86	4.27	NS

*OVH indicates open vein harvesting; EVH, endoscopic vein harvesting.

		Length of	Reoperation	Intravenous	Cost in
Sex	Age, y	Stay, d	Required	Antibiotics	US Dollars
Open vein harvesting					
F	66	8	No	Yes	\$15,769
F	67	3	No	Yes	\$4501
F	66	13	No	Yes	\$19,726
М	73	5	No	Yes	\$5554
F	66	18	No	Yes	\$13,808
М	77	3	Yes	Yes	\$2586
F	85	4	Yes	Yes	\$5179
F	79	26	Yes $\times 2$	Yes	\$75,442
М	72	3	No	Yes	\$5931
F	78	3	No	Yes	\$3925
Mean length of stay		8.6			
Total cost					\$152,421
Mean cost					\$15,242
Median cost					\$5743
Endoscopic vein harvesting					
Μ	76	6	No	Yes	\$4499
М	52	6	No	Yes	\$3492
F	74	6	Yes	Yes	\$8988
М	74	4	No	Yes	\$5198
Mean length of stay		5.5			
Total cost					\$22,177
Mean cost					\$5544
Median cost					\$4849

Table 4.	Medicare	Patient	Readmission	Data*
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*Difference in mean length of stay between the open vein harvesting group and the endoscopic vein harvesting group is not significant.

release of service versus 588 days for an average of 73.5 days per patient in the EVH group. As with the previously discussed data for wound treatment costs, analysis of the home health cost data and the days-of-service data did not yield any statistically significant differences because of the small sample sizes and the skewness in the data.

Table '	5. Home	Health	Care o	of Medicare	Patients:	Number	of Visit	s for	Wound	Treatment*
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Sex	Age, y	OVH, n	Sex	Age, y	EVH, n
M	85	7	М	76	26
F	66	59	М	52	30
F	67	23	М	79	35
F	69	33	F	74	32
F	66	8			123 Total
Μ	73	3			
Μ	77	121			
Μ	72	6			
F	80	9			
F	78	21			
F	67	111			
Μ	68	34			
Μ	68	47			
Μ	71	28			
F	70	46			
		556 Total			

*Difference in number of visits per patient between the open vein harvesting (OVH) and endoscopic vein harvesting (EVH) subgroups was not significant.

Table 6. Days of Service from Date of Surgery to the Final Office Visit $\!\!\!\!\!\!\!\!\!\!\!$

Open vein harvesting	
No. of wound complications	31
Total, d	2760
Mean, d	89.0
Range, d	30-200
Endoscopic vein harvesting	
No. of wound complications	8
Total, d	588
Mean, d	73.5
Range, d	32-125

*Difference in days of service between the open vein harvesting and endoscopic vein harvesting subgroups was not significant.

CONCLUSION

In conclusion, this retrospective study supports the evidence that EVH is an improved technique, even in the Medicare patient population in which statistically significant comorbid conditions known to cause leg wounds are present. Not only were there significant differences as expected in comorbid conditions between the Medicare and the non-Medicare populations, there were also differences between the OVH and EVH subgroups of the Medicare population. Despite these factors, the EVH group continued to demonstrate a lower rate of wound complications than the OVH group.

This study is the first to attempt to specifically examine the costs of leg wounds with regard to readmission, home health care, and office use. Despite the lack of statistical power in these comparisons due to a small sample size, the conclusion appears reasonable that when wound complications do occur, both the per-patient costs and the aggregate costs of treating the entire population were substantially lower in the EVH patient group than in the OVH population. Despite the lack of statistical significance in the analysis of length of stay on patient readmission, the average length of stay is more than 3 days longer for patients with an OVH leg

Table 7. Cost Data*

	OVH	EVH
	(n = 1168)	(n = 741)
Surgical supplies/patient†	\$350	\$650
Surgical supplies (total)	\$408,800	\$481,650
Readmission costs	\$152,421	\$22,177
Home health costs	\$55,600	\$12,300
Cost of additional day (end of stay)†	\$500	\$500
Length of stay reduction, d	0	0.2
Saved cost from reduced length of stay	0	-\$74,100
Total cost	\$616,821	\$442,027
Cost per patient	\$528	\$596

*OVH indicates open vein harvesting; EVH, endoscopic vein harvesting. †Cost data from [Makary 2000]. complication (Table 4). These data specifically examined readmissions, but they suggest that leg wound complications delay initial hospital discharge as well. Because of the reduction in infection rates, there should be a net total reduction in the costs and resource consumption associated with the treatment of these complications. We excluded the costs of initial wound care involved with the two methods because of the near impossibility of recording these costs accurately. Postoperatively, EVH wounds are covered with a small Band-Aidlike dressing and wrapped with an Ace bandage for 24 hours. Essentially, no postoperative wound care is needed. Additional suture is routinely required with OVH for the longer incisions, and 1 to 2 staple devices are used for obese legs. Ace bandages are then used as with EVH wounds. Typically, OVH legs have varying amounts of serosanguineous fluid that drain, require additional dressing material, and occasionally require additional antibiotic coverage; therefore, treating such cases costs more initially for adequate in-hospital wound care. The higher per-patient costs of the EVH group are secondary to the cost of disposables. Published reports have shown that the higher costs in the EVH population can be offset by decreasing the length of stay (0.5-1.5 days), and the costs can be calculated in terms of dollars saved [Makary 2000, Patel 2001] (Table 7). Theoretically, if the actual incidence of OVH wound complications were in the modest range of 5% to 6% or higher (previously reported rates were 2% to 24% [Goldsborough 1999]) or if the length of stay were improved beyond that of our experience, then such changes obviously would offset the added costs of disposables and on the basis of per-patient cost would further justify performing EVH.

Reducing overall costs and improving quality are important goals in today's health care environment, even in the face of declining reimbursements, especially in the Medicare population. This situation is particularly true for hospitals under the prospective payment systems that have substantial incentives to minimize the incidence of postoperative wound complications [Boyce 1990]. Although there is clearly a need to demonstrate more rigorously the reduced costs of EVH (which only a multicenter trial can provide), the evidence is overwhelming regarding the benefit to our patients, especially to the Medicare population despite its high incidence of comorbid conditions.

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