Cost Savings Associated With a Multidisciplinary Protocol That Expedites Definitive Fracture Care

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Abstract

Changes in health care reimbursement will reward systems that can improve patient outcomes and reduce costs. We implemented an integrated-care pathway protocol that coordinates the efforts of all the teams involved in the care of multiple-trauma patients by providing standard resuscitation parameters to recommend timing of definitive fracture fixation. The Early Appropriate Care (EAC) protocol was projected to reduce complications and length of stay (LOS) in the hospital. We propose to calculate the projected cost savings associated with reductions in complications and shorter LOS from implementing the protocol.

To determine complication rates, LOS, and costs of care, we reviewed the cases of 1114 patients treated surgically for femur, pelvis, or acetabulum fractures between 2000 and 2006.

Complications increased LOS by 12.2 days in femur patients and 13.8 days in pelvis and acetabulum patients. Mean additional cost per day was $4368 for femur patients and $4304 for pelvis/acetabulum patients. Mean cost per complication was $58,968 for femur patients and $98,465 for acetabulum patients. Projecting a 10% reduction in complications with EAC forecasts a $2,746,638 or $2,145,847 reduction in costs based on reduced per-complication costs or reduced LOS, respectively. Initial EAC implementation has resulted in fewer complications with an estimated annual cost reduction of $2,227,151, consistent with the projections. Literature review yielded cost estimates of $2480 per hospital day and $37,772 per complication. These literature estimates forecast total cost savings of $888,940 per reduction in LOS and $1,531,646 per reduction in complications.

In spite of the wide range of estimates for the total cost reduction, it is clear that the reduction in costs associated with a 10% reduction in complications from implementing the EAC protocol will be substantial. Initial clinical data have shown up to 17% fewer complications with EAC adherence, which is projected to reduce our hospital costs by $2 million per year. These cost reductions justify further investment in refining the EAC protocol and securing hospital resources needed to support further implementation.

The US health care industry will face unprecedented challenges over the next several decades. Changes in reimbursement criteria and patient demographics have already affected patient care. Medicare's recent decision not to pay for charges associated with several types of complications seems to provide a preview of a new data-driven paradigm that will reward hospitals that are able to meet health care quality standards.[1,2] Concurrent with these trends are numerous reports of emergency departments and trauma programs closing because of fiscal insolvency.[3,4] One-fourth of the emergency departments that existed 2 decades ago have closed.[5] While emergency facilities are closing, our population is aging and will require more care.

Integrated-care pathways and other "second-curve" innovations may help address some of these challenges.[6] Integrated-care pathways reduce costs and improve patient outcomes by increasing communication across disciplines and providing a known framework. However, successful implementation of procedures as basic as hand-washing and use of surgical checklists requires resources.[7] In an environment in which health care resources are scarce, it is important to gauge the ability of an integrated-care plan not only to provide substantive benefits to patients but to justify the financial return on investment required to successfully implement the program.

In this article, we evaluate the financial impact of the theoretical reductions in complications associated with the implementation of the Early Appropriate Care (EAC) protocol at a level I urban trauma center.[8] This protocol aims to definitively stabilize mechanically unstable spine, pelvis, and femur fractures within 36 hours after injury, as long as the patients

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are adequately resuscitated. The EAC protocol was developed to provide clear indications for damage-control orthopedics, as opposed to early definitive fracture care. The protocol increases cooperation and understanding among the trauma/critical care, anesthesia, orthopedics, and other surgical services involved in patient care by defining specific parameters and timelines that are easy to remember and implement. The mathematical models used to design the protocol suggested that successful implementation could reduce both complications and length of stay (LOS) in the hospital. Initial results validate these premises.[9] Our goal in this project was to project the financial benefit of the protocol, generated through the reductions in complications and LOS predicted by the model.

Materials and Methods

This retrospective study was conducted at MetroHealth Medical Center in Cleveland, Ohio, and was approved by the center's institutional review board (IRB). We reviewed an IRB-approved database and identified skeletally mature patients treated for high-energy femur fractures, pelvic ring injury, or acetabulum fractures. Charges and payments were determined for all the femur patients during the initial hospitalization and all subsequent trauma-related care for a 6-month period. Inpatient and outpatient rehabilitation was not included in the analysis. Six hundred six patients with femur fractures and 508 patients with pelvis or acetabulum fractures had complete financial records, including facility and professional charges and collections. Total charges consisted of all facility charges for supplies, implants, nonphysician staff, ancillary services, and other resources required for care, as well as professional charges associated with services provided by all treating physicians. Payment was the actual amount collected on the total bill. All charges and payments were standardized to account for known annual charge increases and were adjusted to 2013 levels. Of note, *charge* differs from *cost*, which is defined as the actual costs, both direct and indirect, of providing hospital services.

> Reductions in complications would not only reduce costs but likely would lead to increases in patient volume and contribute to the total margin, which is a more vital figure for the financial viability of the institution than contribution margin is.

Intensive care unit (ICU) LOS and hospital LOS were determined. ICU stays included all regular and step-down ICU days, whereas standard hospital units may or may not have had additional monitoring capabilities, such as telemetry or sleep apnea, but still were considered part of the non-ICU hospital stay. Complications included surgical wound infection, pneumonia, acute respiratory distress syndrome (ARDS), pulmonary embolism (PE), deep venous thrombosis (DVT), acute renal failure (ARF), sepsis, multiple-organ failure (MOF), and death. Pneumonia was defined as a new persistent infiltrate on chest radiograph, positive sputum culture, temperature higher than 38°C, and white blood cell count of 10×10^9/mL. Criteria for ARDS were acute onset of bilateral pulmonary infiltrates on chest radiography, and PaO_2:FiO_2 (ratio of partial pressure arterial oxygen and fraction of inspired oxygen) of 200 mm Hg for 4 consecutive days in the absence of pneumonia and pulmonary edema. PE was diagnosed by computed tomography. DVT was diagnosed by positive duplex ultrasound proximal to the knee. ARF was defined as renal insufficiency requiring hemodialysis. Sepsis was defined as infection manifested by positive blood culture and at least 2 of the following: temperature higher than 38°C, heart rate higher than 90 beats per minute, respiratory rate 20 breaths per minute, and white blood cell count of 12×10^9/mL. MOF was defined as failure of 2 or more organ systems.

Facility costs were calculated based on information from accounting records obtained for the 606 femur patients. These were adjusted to 2013 levels based on inflation rates. Direct expenses included fixed and variable components for staffing (nonphysician) salaries, benefits, and other expenses, as well as supplies and implants. Indirect expenses included overhead costs for administration and environmental maintenance. The charge-to-cost ratio calculated on the basis of these femur patents was used to estimate costs for pelvis and acetabulum patients from the available charge information. Cost per additional hospital day for each group was calculated using a linear regression model in Excel (Microsoft, Redmond, Washington) validated using R^2 as a parameter, with $R^2 > 0.95$ considered significant. The cost increase associated with a patient sustaining any complication was determined from the difference of the mean costs, and the significance of the differences in the means were evaluated using the t test in Excel.

Finally, data regarding increases in LOS for patient complications, costs for additional days in the ICU and on the regular surgical unit, and costs associated with incidence of various complications were extracted from the published literature. These data were averaged to create a consensus figure for the cost per hospital day, cost of a complication, and increase in LOS associated with a complication. All data were inflation-adjusted to 2013 levels.

Information from our own databases and from the literature was used in 2 separate models to estimate the cost savings associated with a 10% reduction in the complication rate. We chose this reduction based on the premise of the EAC protocol. The first model estimated the cost by evaluating only the cost decrease associated with a shorter LOS; the second estimated the cost by evaluating the cost decrease associated with fewer complications. These models were taken as 2 estimates of the same cost savings, as LOS and complications have been shown to be so closely related. Cost data (rather than collections or charges) were chosen to eliminate the effects of payer mix and

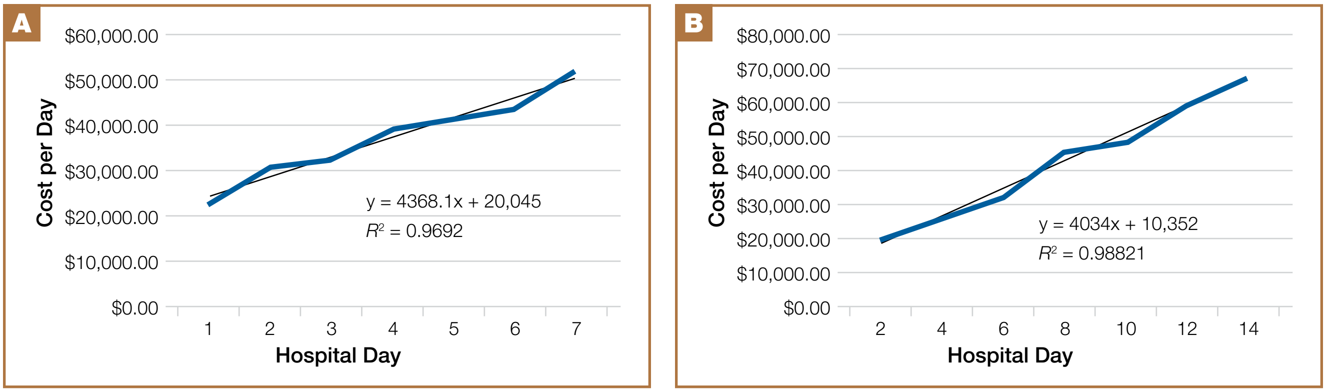

Figure. Total cost per hospital day in patients with (A) femur fractures and (B) pelvis and acetabulum fractures.

charge inflation on the results. We reviewed the initial clinical data regarding complications and LOS for patients treated with the EAC protocol over 20 months. These data were used to validate the projections in cost savings.

Results

Of the 606 femur fracture patients, 94 (15.5%) had complications. A complication in a femur fracture patient was associated with a mean increase of $58,968 in total cost to the hospital: $110,342 (SD, $74,604) with a complication and $51,374 (SD, $48,142) without a complication ($P < .0001$, **Table I**). Mean increase in LOS for patients with a complication was 12.2 days: 19.0 days with a complication and 6.84 days without a complication ($P < .01$). The cost associated with each additional hospital day was $4368 ($R^2 > 0.95$; **Figure A**). The cost-to-charge ratio for femur fractures was 0.496, and the cost-to-collections ratio was 1.134.

Of the 508 pelvis/acetabulum fracture patients, 84 (16.5%) had complications. A complication in a pelvis or acetabulum fracture patient was associated with a mean increase of $98,465 in total cost to the hospital, based on the mean cost found using the cost-to-charge ratio and the cost-to-collections ratio from the femur patients: $143,382 (SD, $94,977) total cost with a complication and $44,917 (SD, $37,196) without a complication (**Table II**). Mean increase in LOS for patients with a complication was 13.8 days (22.5 days with a complication, 8.71 days without a complication ($P < .0001$). The cost associated with each additional hospital day was $4034 ($R^2 = 0.99$; **Figure B**).

Table I. **606 Patients With Multiple-System Trauma Were Treated for Femur Fractures**

	Patients Without Complications		Patients With Complications		
	Mean	SD	Mean	SD	*P*
Age, y	35.5	15.2	39.6	17.3	.03
Injury Severity Score	21.6	11.0	34.1	13.2	< .0001
Hospital stay, d	6.84	6.0	19.0	14.0	< .0001
Financial data, US $					
Total cost of care	$51,374	$48,142	$110,342	$74,604	< .0001
Charges for care	$99,901	$93,259	$242,810	$147,064	< .0001
Total payments	$42,149	$49,066	$114,536	$91,245	< .0001

Table II. **508 Patients With Multiple-System Trauma Were Treated for Pelvis and Acetabulum Fractures**

	Patients Without Complications		Patients With Complications		
	Mean	SD	Mean	SD	*P*
Age, y	39.8	15.2	40.8	13.5	NS
Injury Severity Score	23.2	10.9	37.8	13.2	< .0001
Hospital stay, d	8.71	7.1	22.5	14.5	< .0001
Financial data, US $[a]					
Total cost of care	$44,917	$37,196	$143,382	$94,977	< .0001
Charges for care	$96,243	$74,583	$281,336	$164,661	< .0001
Total payments	$37,123	$32,980	$129,825	$95,486	< .0001

[a]Costs were calculated from mean charge and payment (collection) ratio.
Abbreviation: NS, not significant.

Table III. **Summary of Hospital Day Costs Based on Weighted Mean of Costs From Published Literature**

		Cost, US $	
Type of Hospital Stay	Year	Actual	Inflation-Adjusted to 2013
Regular Surgical Floor			
Fine & colleagues[11]	2000	$680.00	$1132.25
Milbrandt & colleagues[12]	2008	$1488.00	$2117.89
de Lissovoy & colleagues[13]	2009	$2149.00	$2514.03
			$1921.39 (mean)
ICU			
Kappstein & colleagues[14]	1992	$869.00	$1980.25
Pittoni & Scatto[15]	2009	$2666.00	$3118.84
Milbrandt & colleagues[12]	2008	$2575.00	$3665.03
Dasta & colleagues[16]	2005	$3184.00	$4357.52
			$3008.61 (mean)
ICU With MV			
Thompson & colleagues[17]	2006	$2553.00	$3359.57
Pittoni & Scatto[15]	2009	$3228.00	$3776.30
Dasta & colleagues[16]	2005	$968.00	$5430.48
			$4188.79 (mean)

Abbreviations: ICU, intensive care unit; MV, mechanical ventilation.

Incidence of fractures of interest per year was averaged for the years 2011 and 2012. On average, 238 femur patients, 90 pelvis/acetabulum patients, and 77.5 spine patients were treated surgically each year. Reducing the rate of complications by 10% would reduce the number of complications in femur, pelvis/acetabulum, and spine patients by 24, 9, and 8 patients, respectively. We used the cost of a complication for a femur patient as a conservative model for the cost of a complication for a spine patient because the complication after femur fracture generated a lower level of cost. Fewer complications after femur (n = 23.8), pelvis/acetabulum (n = 9.0), and spine (n = 7.8) fractures per year at a cost of $58,968, $98,465, and $58,968 each, respectively, would yield an annual reduction in cost of $2,746,638. Reducing the same patients' hospital LOS by the mean difference in LOS between complicated and uncomplicated patients would result in a cost savings of $2,145,847 per year.

Initial implementation of the EAC protocol at our hospital has resulted in fewer complications and shorter hospital stays in patients treated definitively within 36 hours after injury for the fractures of interest.[9] These have included patients with an Injury Severity Score (ISS) of 16 or higher over 20 months, who were treated for femur fractures (n = 137), pelvis/acetabulum fractures (n = 90), and spine fractures (n = 83). Mean age of EAC patients was 40 years, and mean ISS was 26, not significantly different from the means of the patients on whom we based the projections (**Tables I, II**). Complications decreased from 33% to 16% with adherence to EAC protocol recommendations. LOS decreased from 17.3 days to 9.5 days. Patients who developed complications had the longest mean LOS, 19.8 days (vs 8.7 days for an uncomplicated course), a mean increase of 11.1 days.[9] The reduction in complications in these initial patients treated with the EAC protocol is estimated to be associated with a decrease in annual costs of $2,227,151, using the cost-to-collections ratios determined above. The reduction in LOS in patients without complications—versus a mean of 9.81 days in a pre-EAC group of patients with similar injuries and mean ISS without complications, treated at our hospital for the same fractures[10]—was 1.1 days. Thus, the reduction in cost associated with a shorter hospital stay in EAC patients without complications, versus our historical practice, is projected to save another $709,807 per year.

A search of the literature revealed wide-ranging estimates of costs for ICU days, hospital days, ventilator days (**Table III**), and various kinds of complications (**Table IV**) as well as the increase in LOS attributable to a specific complication (**Table V**).[10-37] In aggregate, the mean cost per additional day in the hospital was $2480. The increase in LOS attributable to a complication was 8.842 days. The overall increase in hospital cost associated with any complication was $37,772. Together, these figures project cost savings of $1,531,646 based on complications, or $888,940 based on LOS.

Discussion

Studies have shown that increases in LOS account for nearly 80% of the variation in hospital costs associated with complications.[24] Therefore, it does not make sense to combine estimates of cost reduction calculated from LOS or occurrence of complications without controlling for the other variable. In this article, we projected the costs associated with only one or the other as a reasonable approximation of the total cost savings associated with the overall improvement in patient outcomes. We also projected the cost savings in reduced LOS associated with adherence to the EAC protocol in patients who never had a complication, when compared with a historical group of uncomplicated patients treated for similar fractures before EAC.[10]

In this study, we evaluated the effects of the protocol on hospital costs rather than on charges or collections because of the varying effects of payer mix on those data. More than 70% of the payer mix in our hospital consists of Medicare, Medicaid, or uninsured. These payers have been shown to yield collections below costs; therefore, in this hospital, cost reductions are additions to the bottom line. Although much has been made recently of the difference between direct and indirect costs, and the additional revenue resulting from treatment of surgical complications, arguments that hospitals have financial incentives not to reduce complications and prolong LOS lack merit for busy level I regional trauma centers.[38] Although com-

Table IV. **Summary of Costs Associated With Complications, as a Group (A) and by Type (B), in Published Literature**

(A)		Cost, US $	
Study	**Year**	**Actual**	**Inflation-Adjusted to 2013**
Whitmore & colleagues[18]	2012	$4140.00	$4284.90
Dimick & colleagues[19]	2003	$4007.00	$5652.27
Dimick & colleagues[20]	2006	$10,178.00	$12,949.26
Dimick & colleagues[21]	2004	$11,626.00	$15,845.04
Kalish & colleagues[22]	1995	$16,023.00	$29,762.55
O'Keefe & colleagues[23]	1997	$24,191.00	$44,934.52
Siegel & colleagues[24]	1994	$78,530.00	$150,974.03
			$37,771.80 (mean)
Total cost by complications		$1,531,646.32	
Cost per complication		$37,771.80	
Reduction in complications		10%	
No. of patients per year		405.5	

(B)			Cost	
Study	**Year**	**Complication**	**Actual**	**Inflation-Adjusted to 2013**
Jarvis[25]	1996	Pneumonia	$4974.00	$8878.26
Kappstein & colleagues[14]	1992	Pneumonia	$8800.00	$18,123.00
Penel & colleagues[26]	2008	Pneumonia	£19,000.00	$31,366.80
Thompson & colleagues[17]	2006	Pneumonia	$28,161.00	$35,828.66
				$23,549.18 (mean)
Herwaldt & colleagues[27]	2006	Surgical site infection	$3021.00	$3843.56
Jarvis[25]	1996	Surgical site infection	$2734.00	$4906.64
Kirkland & colleagues[28]	1999	Surgical site infection	$3089.00	$5000.15
de Lissovoy & colleagues[13]	2009	Surgical site infection	$20,842.00	$23,107.90
Whitehouse & colleagues[29]	2002	Surgical site infection	$17,708.00	$25,853.14
Penel & colleagues[26]	2008	Surgical site infection	£17,000.00	$28,065.03
				$15,129.40 (mean)
Sheng & colleagues[30]	2005	Nosocomial infections	$197,460.00	$7800.51
Rajakaruna & colleagues[31]	2005	Prolonged ventilation	$11,525.00	$15,176.22
Zilberberg & Luippold[32]	2008	Prolonged ventilation	$28,463.00	$33,805.12
Jarvis[25]	1996	Sepsis	$3061.00	$5493.50
Herwaldt & colleagues[27]	2006	Sepsis	$23,520.00	$29,924.01
Jarvis[25]	1996	Urinary tract infection	$558.00	$1001.43
Herwaldt & colleagues[27]	2006	Urinary tract infection	$6219.00	$7912.30

plications increase contribution margins, they reduce the total margin.[39] For many hospitals with significant unfilled capacity, there may be an incentive to collect additional revenue from additional patients. However, total margin reductions are not sustainable. Studies have shown reductions in LOS and complications lead to increased volume in busy trauma centers, as a larger total number of patients can be treated within the same time frame.[40] Therefore, reductions in complications

Table V. **Increase in Length of Hospital Stay Associated With Various Complications**

Study	Complication	Mean Additional Hospital Days
Hellsten & colleagues[33]	Adverse perioperative events, spine	3.6
Thompson & colleagues[17]	Hospital-acquired pneumonia	11
Dasta & colleagues[16]	Mechanical ventilation	5.9
Erbaydar & colleagues[34]	Nosocomial infection	10.6
Sheng & colleagues[30]	Nosocomial infection	18
Asensio & Torres[35]	Surgical site infection	14
Kirkland & colleagues[28]	Surgical site infection	6.5
Merle & colleagues[36]	Surgical site infection	3.5
de Lissovoy & colleagues[13]	Surgical site infection	9.7
Schulgen & colleagues[37]	Surgical site infection	10
Kappstein & colleagues[14]	Ventilator-associated pneumonia	10.3
		8.842 (mean)

would not only reduce costs but likely would lead to increases in patient volume and contribute to the total margin, which is a more vital figure for the financial viability of the institution than contribution margin is.

Rosenthal[2] wrote that the recent change in Medicare payment to deny reimbursement for some preventable complications represents a symbolic change in approach for Medicare payment that will lead to greater accountability for quality of care. Indeed, Medicare has already stated intentions to begin "pay-for-performance" programs that would reward hospitals for positive outcomes.[41] These developments would further reward health care systems that are able to implement cost-effective integrated-care pathways.

The need for innovation to push the "second curve" of health care and improve outcomes also provides an impetus to show the cost-effectiveness of integrated-care pathways during implementation. The EAC protocol did not require new resources. Availability of specialty providers, operating rooms, and related support staff/assisting physicians, equipment, and supplies was unchanged. However, our trauma center may be unique among trauma systems in that traumatologists capable of performing these procedures are available at all hours every day of the year, and our operating room maintains a trauma room for such cases each day. During our initial EAC experience, 1.5% of all patients were delayed because the operating room was unavailable.[9] We did not measure the effects of availability of hospital support services or the effects of day of week of injury on throughput. Operational enhancements likely provide services (eg, orthotics) every weekday, and home care arrangements would expedite patient throughput even more, resulting in shorter LOS. Our findings suggest that investing in the development of new, innovative health care strategies can be profitable. Furthermore, it would be prudent to reinvest some of those savings into "product development," much as in any other industry. In this case, the savings would be wisely reinvested in further refining the protocol. For example, further study into the applicability of the protocol for various subset populations, such as elderly patients or patients with underlying medical conditions, could be clinically and financially beneficial. Further study of operational enhancements, such as the use of alternative operating room staffing models to facilitate early definitive fixation, could also be worthwhile.

The estimates of cost savings produced by the analysis of the data available at our hospital for LOS and complications were within 30% of each other. The actual cost of these patients was probably some composite of the 2 estimates. The estimates for cost savings with the EAC protocol, based on fewer complications, fall between the 2 estimates. All our estimates are confounded by the significantly higher ISS for the group with complications. This injury indication suggests that the costs for this group would have been higher anyway. In spite of the difference between the 2 estimates and the potential confounding effects of disparate ISS on the data, significant cost savings can be realized by reducing complications associated with implementation of the EAC protocol.

One way to estimate the cost without regard to the confounding of ISS is to use the mean values of cost of complications and LOS from the literature. This estimate produced costs in the range of $900,000 to $1.5 million. Many of the estimates in this literature group were from patients who were much less severely injured than our sample was. The cost of complications likely is higher in patients with multiple-system injury than in the general hospital population. Data from the literature still project a significant savings because of the estimated reduction in complications from the adoption of the EAC protocol.

Conclusion

Initial results from the EAC protocol implementation indicate that complications have decreased even more than estimated. The protocol is associated with improved patient outcomes and cost savings, according to the calculations presented here. The protocol relies on existing resources and fixed costs. For other hospitals, the projected savings may justify acquiring or developing personnel and other resources in support of the protocol, as the revenue appears to substantially exceed expenditures.

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