

RESEARCH

Cost Comparison of Elective Invasive Procedures between Elderly and Non-Elderly Patients at an Academic Medical Center

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The objective of this study was to determine whether a correlation exists between patient age and hospital expenditures for common complex elective surgical procedures. Hospital charges at an urban academic medical center were categorized by diagnosis related group (DRG) and separated into two cohorts based on patient age (≥ 65 years old and < 65 years old). The costliest elective procedures were identified and the average total hospital cost per procedure was calculated for each group. A Student t-test was performed to compare the average cost per procedure in each cohort and a linear regression model was performed to assess whether a linear correlation existed between patient age and cost per case. Among the costliest elective procedures identified, major elective cardiovascular, spine, and intestinal procedures were costlier in patients ≥ 65 years. Major transplantation, vascular procedures, and joint replacement surgery were not costlier. Further, none of the identified procedures demonstrated a linear correlation between patient age and cost per case. This finding, combined with other outcome measures, may allow us to re-examine the age limits for these complex procedures.

Keywords: cost comparison; elderly; geriatric; elective surgery

Introduction

There is a perception that age is a cost driver for complex elective procedures. An evaluation of the costliest elective interventional procedures among the elderly and non-elderly populations may provide information about the relationship between age and total hospital costs. The objective of this study was to determine whether a correlation exists between patient age and hospital expenditures for common complex elective surgical procedures.

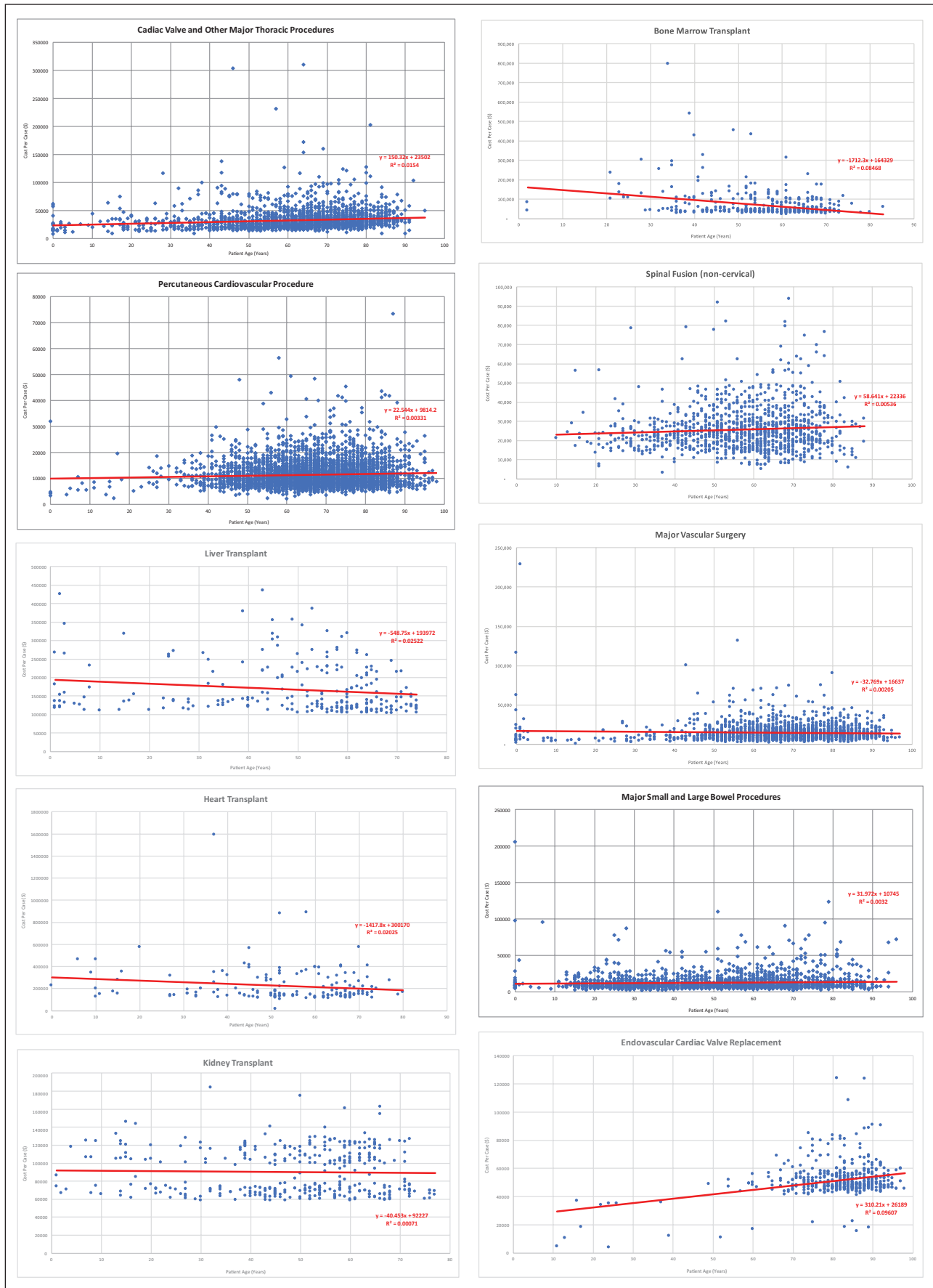
Methods

Data for this study were obtained from The Mount Sinai Hospital's financial database, including only those patients that underwent an elective inpatient procedure, defined as any scheduled non-emergency procedure, between January 1, 2015 and December 31, 2016. All non-elective surgical encounter data were excluded. Patient data for each procedure were categorized by diagnosis related group (DRG) and analyzed to determine which procedures generated the greatest hospital expenditures.

Total hospital expenditures were defined as the direct costs incurred by the hospital for all inpatient encounters associated with a particular DRG (e.g. operating room time, nursing, ancillaries, supplies, implants, complications, etc.). Upon identification of the 16 costliest elective invasive procedures, patient encounter data were separated into two cohorts (≥ 65 years old and < 65 years old). The average cost per case within each cohort was calculated for each of the identified procedures, and Student t-tests were performed to compare costs between cohorts. Linear regression models were then performed to assess whether a linear correlation existed between patient age and cost per case for each procedure. Microsoft Excel was used to perform all statistical analyses.

Results

After reviewing 114,448 hospital admissions (33,803 aged ≥ 65 years and 80,645 aged < 65 years), the 16 most costly elective procedures were identified. These 16 procedures represented 36% of overall hospital expenditures. As seen in **Table 1**, the following 8 procedures were statistically more expensive for patients aged ≥ 65 years: cardiac valve/other major cardiothoracic procedure, endovascular cardiac valve replacement, percutaneous cardiovascular procedure, coronary bypass, major bowel procedures, and spinal fusions (cervical, non-cervical, and non-cervical with spinal curvature/malignancy/infection). The remaining 8 procedures – transplantation (liver, heart, kidney, bone marrow),



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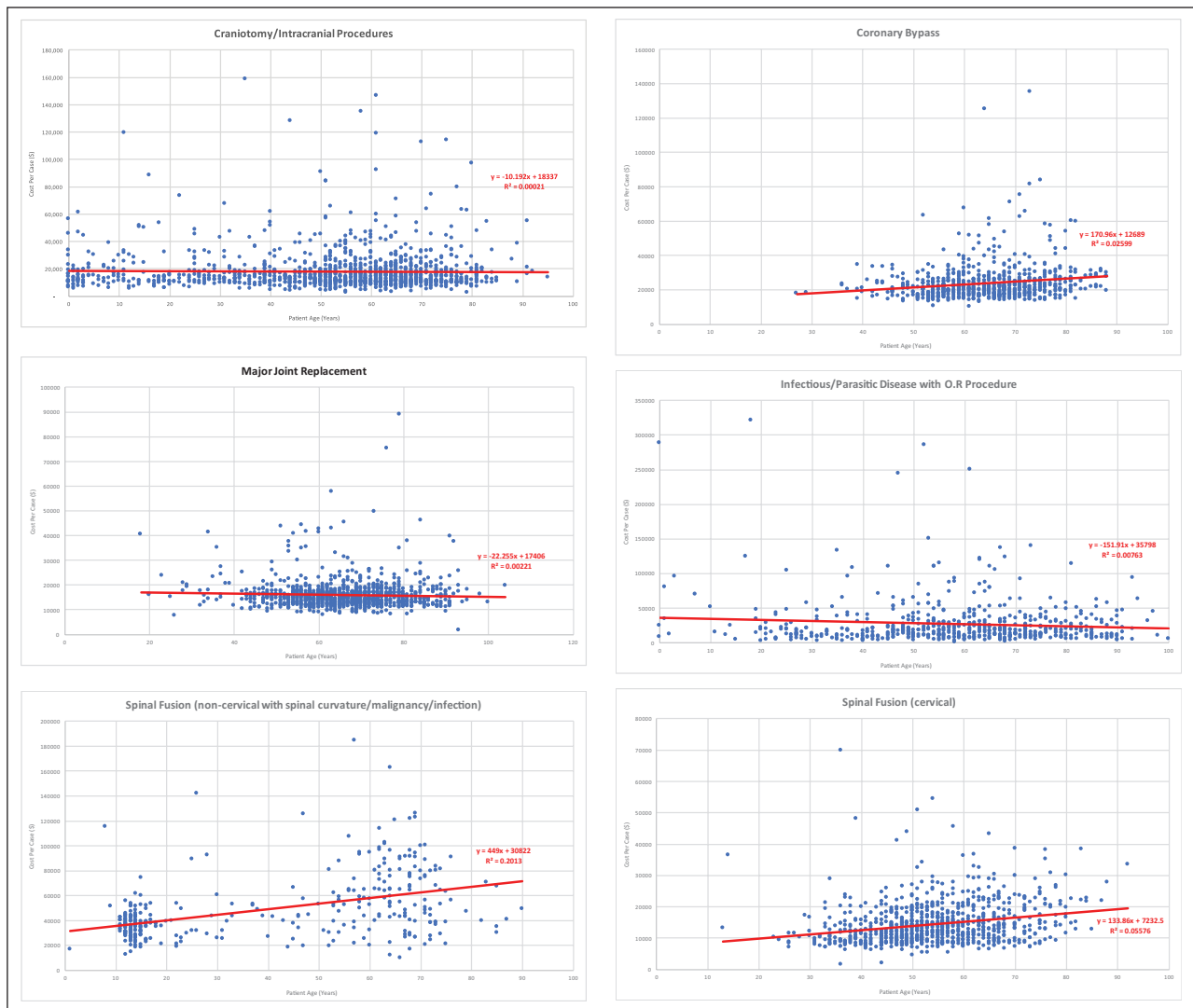


Figure 1: Patient Age vs. Cost Per Case scatter plots for each of the 16 costliest elective invasive procedures performed at an academic medical center.

Table 1: Elective Procedures More Costly Among the Elderly.

#	MS DRG Description	# of Cases ≥65 y.o	# of Cases <65 y.o	Cost/Case Differential	Percentage Differential	P-value
1	Endovascular Cardiac Valve Replacement	454	24	\$ 16,418.41	+46%	<0.001
2	Spinal Fusion (non-cervical with spinal curvature/malignancy/infection)	81	270	\$ 14,625.87	+33%	<0.001
3	Cardiac Valve/Other Major Cardiothoracic Procedure	1061	1043	\$ 4,071.44	+13%	<0.001
4	Spinal Fusion (cervical)	171	675	\$ 2,685.30	+19%	<0.001
5	Spinal Fusion (non-cervical)	400	711	\$ 2,270.38	+9%	0.0028
6	Coronary Bypass	359	346	\$ 2,544.95	+11%	0.0016
7	Major Small & Large Bowel Procedures	616	1575	\$ 2,037.98	+17%	<0.001
8	Percutaneous Cardiovascular Procedure	2551	1794	\$ 469.54	+4%	0.0017

Rankings of the largest cost differentials between the elderly (≥65 years) and non-elderly (<65 years) populations for the costliest elective surgical procedures that were statistically determined to be more expensive for elderly patients.

Table 2: Linear Regression Results for Elective Procedures More Costly Among the Elderly.

#	MS DRG Description	Age vs. Cost/Case R ² Values*
1	Endovascular Cardiac Valve Replacement	0.096
2	Spinal Fusion (non-cervical with spinal curvature/malignancy/infection)	0.201
3	Cardiac Valve/Other Major Cardiothoracic Procedure	0.015
4	Spinal Fusion (cervical)	0.056
5	Spinal Fusion (non-cervical)	0.005
6	Coronary Bypass	0.026
7	Major Small & Large Bowel Procedures	0.003
8	Percutaneous Cardiovascular Procedure	0.003

Rankings of the costliest elective surgical procedures determined to be statistically more expensive among elderly patients (≥ 65) and their associated R² values derived from linear regression modeling of patient age vs. cost/case. *Note: R² represents the strength (scored from 0.0–1.0) of the linear relationship between patient age and cost/case.

major vascular surgery, craniotomy/intracranial procedures, infectious/parasitic disease procedures, and major joint replacement were not statistically more expensive.

Although 8 of the 16 analyzed procedures were statistically costlier for patients aged ≥ 65 years, none demonstrated a correlation between patient age and cost per case (**Figure 1**). Among the identified procedures, the associated R² values following linear regression modeling ranged from 0.003 to 0.201 (**Table 2**), where R² represented the strength (scored from 0.0–1.0) of the linear relationship between patient age and cost per case [1].

Discussion

This analysis has identified some of the costliest elective procedures performed at an academic medical center and determined which of those procedures are more expensive to perform on elderly patients. However, to define the age of 65 years as the dividing line between elderly and non-elderly patient populations is certainly arbitrary, and does not necessarily reflect a change in health status or increased cost burden [2]. Rather, age 65 is oft cited as the dividing line between older and younger adults simply due to its historical ties to the age of retirement, which came about in large part due to the state pension systems in place during 1935, as well as the age of Medicare eligibility, which was introduced in 1966 as a means to make health insurance more affordable to individuals aged 65 and older who had previously paid more than three times as much for health insurance compared to younger adults [3, 4]. Age is a continuum, and when evaluated as such via linear regression, no relationship was found between age and cost.

Previous studies have shown mixed results regarding the impact of patient age on cost. One study that examined the relationship between age and cost among all surgical patients at an academic medical center found that financial risk (i.e. cost to the hospital) increased with the age of the patient [5]. However, it is important to note that this study examined all surgeries within the hospital whereas the present study examined only the costliest elective procedures. Another study found that among patients undergoing anterior cervical fusion, those aged 65 years and older were independently associated with a statistically significant increase in total costs [6]. This finding is consistent with the results of the present study when patients aged ≥ 65 years are assessed as an independent cohort, but deviates from the present study's findings when age is examined as a continuum via linear regression.

Other studies have found that factors such as patient frailty index and comorbidities are superior indicators for increased healthcare costs [7]. More specifically in the case of cardiac procedures, which accounted for 4 of the 8 identified procedures costlier among older adult patients, frailty has been found to be associated with a marked increase in postoperative hospitalization costs after adjusting for age, sex, surgery type, and surgical risk score [8]. On the other hand, it has also been reported that among octogenarians and septuagenarians undergoing cardiac surgery, total direct cost was higher in the older group of patients [9]. Perhaps if the present study analyzed a narrower patient age range or divided the patient population into more than two cohorts (e.g. by decade), we may see similar differences in cost. Regardless, further analysis of the identified procedures is required to determine the root cause of cost differences between cohorts as age alone is not a reliable predictor of cost.

Although several of the identified procedures reflect a degree of asymmetry between the number of cases performed in each cohort, the case mix derived from the academic medical center in this study correlates well with that of national data. For instance, while only 5% of the endovascular cardiac valve replacement population was < 65 years old in the present study, JAMA similarly reported that among patients undergoing transcatheter aortic valve replacement in 2015, 6.1% were aged ≤ 65 years [10]. Comparably, in the case of spinal fusions, the present study demonstrated that only 28% of sampled patients were aged ≥ 65 years. This percentage was consistent with previous findings, one of which reported that in 2008, approximately 26.5% of patients undergoing spinal fusion were over the age of 65 [11].

This analysis was limited by the fact that cost data was based entirely from the hospital's financial database and therefore could not be risk adjusted for clinical risk factors including comorbidities, case complexity, gender, socioeconomic status, and pre-procedure health status. Therefore, higher risk patients requiring longer lengths of stay or increased perioperative care could potentially skew the cost data in the event that these patients were overrepresented in a particular cohort, namely the elderly cohort. Furthermore, although the calculated cost/case accounted for all hospital expenditures associated with a given patient encounter, it did not account for post-discharge costs such as rehabilitation, outpatient care, and patient readmissions.

Ultimately, these economic findings suggest that age is not an independent predictor of cost with respect to elective surgical procedures, and if combined with other outcome-based findings, may allow us to re-examine the age limits for these complex interventions.

Competing Interests

The authors have no competing interests to declare.

Author Contributions

- Study design: AMR, IML
- Data Acquisition: AMR, KF
- Manuscript preparation: AMR, KF, IML
- Critical revision of manuscript: AMR, KF, IML
- Final approval of manuscript: AMR, KF, IML

Sponsor Role

The study protocol was reviewed by the Institutional Review Board of the Icahn School of Medicine at Mount Sinai and determined to be exempt.

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