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Research Paper

Utilization of cardiac computed tomography angiography and outpatient invasive coronary angiography in Ontario, Canada

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ABSTRACT

Background: Cardiac computed tomography angiography (coronary CTA) has emerged as a non-invasive method of diagnosing coronary artery disease. The extent of utilization and uptake of this technology since initiation of its funding by the government of Ontario is unknown.
Objectives: The aim of our study was to examine coronary CTA utilization and the rates of elective invasive coronary angiography and revascularization before and after funding initiation.
Methods: We studied all coronary CTAs performed on adults in Ontario after initiation of funding. We also used an interrupted time series analysis to compare the average monthly rates of invasive angiography and revascularization before and after initiation of funding.
Results: There was an initial steep increase in age-and sex-standardized rates of coronary CTA from 5.0 to 11.4/100,000 over the first two quarters after funding initiation. Afterwards, there was a gradual increase in utilization from 11.4 to 17.1/100,000 over two subsequent calendar years. There was a significant reduction in both the mean monthly outpatient invasive coronary angiography (from 20.7 to 19.9 per 100,000 ($p = 0.0004$)) and revascularization (from 4.9 to 4.4 per 100,000 ($p < 0.0001$)) rates in the three years following introduction of the coronary CTA billing code as compared to the three prior to its introduction.
Conclusions: Since the introduction of coronary CTA funding in Ontario, there has been a steady and controlled increase in its utilization. The increasing use of coronary CTA was associated with a reduction in both the rates of invasive angiography and revascularization.

1. Introduction

Over the past few years, coronary computed tomography angiography (Coronary CTA) has been accepted as a non-invasive method for the assessment of coronary artery disease (CAD).[1–11] Since its adoption, it was hoped that coronary CTA would reduce the need for elective invasive angiography and its associated inherent risks.[12,13] However, to date, there has been limited and often conflicting data regarding the utilization of coronary CTA and its impact on downstream invasive coronary angiography.[12,14–17] Thus, coronary CTA's resource utilization patterns as well as its relationship to downstream invasive angiography remain unclear. Further, no studies have assessed invasive angiography rates before and after implementation of coronary CTA at the level of the entire adult population. In Ontario, Canada there is publicly funded universal health care coverage administered by a single 3rd party payer, the Ontario Ministry of Health and Long Term Care.[18,19] Ontario began publicly funding coronary CTA at a re-imbursement rate of 147.50

Abbreviations: ARIMA, autoregressive integrated moving-average model; CAD, coronary artery disease; CTA, computed tomography angiography; OHIP, Ontario health insurance plan.

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Canadian dollars (approximately 121 US dollars or 107 Euros) through the Ontario Health Insurance Plan (OHIP) in April 2011.[19] The aim of our study was to examine the uptake of coronary CTA in the Canadian province of Ontario as well as assess trends in rates of outpatient invasive coronary angiography and revascularization before and after its funding initiation. Addressing this gap in knowledge is important in order to help understand the real-world impact of coronary CTA in today's era of rapidly expanding imaging costs and limited healthcare budgets. Furthermore, this knowledge may potentially assist policy makers in determining appropriate future funding strategies for this technology.

2. Materials and methods

2.1. Study design and data sources

We conducted a population based repeated cross-sectional study of all coronary CTAs performed in Ontario on adults aged 20 years and older between April 1, 2011 and March 31, 2014. The primary data source was the OHIP claims database that contains all physician reimbursement claims. The Registered Person's database was used to obtain demographic information. Median neighborhood income and rural status were obtained by linking the Census Area Profile with patients' postal codes of residence from RPDB using the Postal Code Conversion File. Hospitalizations were determined using the Canadian Institutes for Health Information Discharge Abstract Database (CIHI-DAD).

2.2. Coronary CTA, invasive angiography and revascularization procedures

We included coronary CTAs billed to OHIP from April 1, 2011 through March 31, 2014. Coronary CTA utilization was assessed by the professional OHIP code X235. To avoid duplicate claims, only one coronary CTA was counted per patient per day. Invasive angiography rates were determined using the Cardiac Care Network (CCN) of Ontario Cardiac Registry. The CCN registry is an ongoing prospective registry storing clinical information on all invasive cardiac procedures in Ontario.[20,21] We included patients who had diagnostic angiograms in Ontario between October 1, 2008 and October 31, 2013 for investigation of stable ischemic heart disease. Patients referred for all other indications including acute coronary syndrome, congenital/structural and/or valvular heart disease were excluded. Determination of patient receipt of revascularization procedures (percutaneous coronary intervention or coronary artery bypass grafting) was performed via application of previously validated billing code algorithms.[22]

2.3. Statistical analysis

Quarterly age-and sex-standardized rates of CTA were calculated and expressed per 100,000 persons aged 20 and older. To assess the association between the introduction of the Ontario coronary CTA billing code on monthly angiography and revascularization rates, an interrupted time series analysis was performed using an autoregressive integrated moving-average (ARIMA) model with a step intervention (introduction of the coronary CTA billing code on April 1, 2011) adjusted for seasonality where appropriate. A p value < 0.05 was considered statistically significant. Statistical analysis was performed using SAS version 9.3 (SAS institute, Cary, North Carolina). The project was approved by the research ethics board of the Sunnybrook Health Sciences Centre.

3. Results

3.1. Diffusion and uptake of coronary CTA in Ontario after introduction of the coronary CTA billing code

Between April 1, 2011 and March 31, 2014, there were 17, 069 OHIP claims for coronary CTA (see Table 1). In the first three quarters after fee code initiation (April 1, 2011 to December 31, 2011), there was an increase from 534 to 1229 coronary CTAs. After this, there was a gradual increase of 56% over two years from 1,229 on January 1, 2012, to 1,923 on December 31, 2013. In terms of age and sex-standardized rates, there was an initial steep increase from 5.0 to 11.4/100,000 over the first three quarters after code initiation. After this there was a gradual increase in utilization from 11.4 to 17.1/100,000 over two calendar years (see Fig. 1). The vast majority of patients were scanned as outpatients (93.5%). In contrast to outpatient studies, inpatient utilization of coronary CTA remained relatively flat throughout the study period (See Fig. 2). The mean age of patients at the time of the coronary CTA was 60 ± 12.8 years. The vast majority of patients scanned resided in urban areas (89.4%). Rates of repeat scans within 120 days were low, at 1.2%. Although 76.6% of the referring physicians were cardiologists, 82.7% of the performing physicians were diagnostic radiologists. Thus, there was a very small degree of self-referral (1.4%).

3.2. Introduction of the coronary CTA billing code and invasive angiography rates in Ontario

There was a significant reduction in the mean monthly rates of outpatient angiograms from 20.7 to 19.9/100,000 ($p = 0.0004$) after introduction of the billing code. In terms of absolute numbers, this translated into 1044 fewer angiograms performed annually post vs. pre code introduction. Furthermore, there was a significant reduction in the mean monthly rate of revascularization from 4.9/100,000 to 4.4/100,000 ($p < 0.0001$) after introduction of the code. Of the patients who had a coronary CTA, 7.3% had a subsequent invasive angiogram within 3 months. Out of those revascularized

Table 1
Characteristics of patient receiving and physicians performing coronary CTA in Ontario from April 1, 2011 to March 31, 2014.

Number of coronary CTA scans	17, 069
Outpatient	15,845 (93.5%)
% Male	57.4%
Age at scan (mean ± standard deviation)	60.0 ± 12.8
Income Quintile	
1	2576 (15.1%)
2	3026 (17.8%)
3	3390 (19.9%)
4	3854 (22.6%)
5	4177 (24.5%)
% Rural	10.6%
Repeat coronary CTA within 120 days	185 (1.2%)
Coronary angiography within 120 days	2116 (14.0%)
Same referring and performing physician	246 (1.4%)
Specialty referring	
Cardiology	13,082 (76.6%)
Family medicine	984 (5.8%)
Cardiac surgery	1259 (7.4%)
Other	1774 (10.2%)
Specialty performing/reporting	
Diagnostic radiology	14,116 82.7%
Cardiology	2172 (12.7%)
Internal medicine	45 (0.3%)
Other	736 (4.3%)