Fairness in the coronary angiography queue

Evidence

Études

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Abstract

Background: Since waiting lists for coronary angiography are generally managed without explicit queuing criteria, patients may not receive priority on the basis of clinical acuity. The objective of this study was to examine clinical and nonclinical determinants of the length of time patients wait for coronary angiography.

Methods: In this single-centre prospective cohort study conducted in the autumn of 1997, 357 consecutive patients were followed from initial triage until a coronary angiography was performed or an adverse cardiac event occurred. The referring physicians' hospital affiliation (physicians at Sunnybrook & Women's College Health Sciences Centre, those who practise at another centre but perform angiography at Sunnybrook and those with no previous association with Sunnybrook) was used to compare processes of care. A clinical urgency rating scale was used to assign a recommended maximum waiting time (RMWT) to each patient retrospectively, but this was not used in the queuing process. RMWTs and actual waiting times for patients in the 3 referral groups were compared; the influence clinical and nonclinical variables had on the actual length of time patients waited for coronary angiography was assessed; and possible predictors of adverse events were examined.

Results: Of 357 patients referred to Sunnybrook, 22 (6.2%) experienced adverse events while in the queue. Among those who remained, 308 (91.9%) were in need of coronary angiography; 201 (60.0%) of those patients received one within the RMWT. The length of time to angiography was influenced by clinical characteristics similar to those specified on the urgency rating scale, leading to a moderate agreement between actual waiting times and RMWTs (kappa = 0.53). However, physician affiliation was a highly significant ($p < 0.001$) and independent predictor of waiting time. Whereas 45.6% of the variation in waiting time was explained by all clinical factors combined, 9.3% of the variation was explained by physician affiliation alone.

Interpretation: Informal queuing practices for coronary angiography do reflect clinical acuity, but they are also influenced by nonclinical factors, such as the nature of the physicians' association with the catheterization facility.

Fair queuing for cardiac procedures requires that patients receive care in a timely fashion, with priority determined by factors such as the severity of the patients' symptoms or the risk of an adverse event occurring while waiting.[1–4] Such criteria have been derived, validated and implemented to organize waiting lists for coronary artery bypass graft surgery in Ontario.[2–7] However, formal queuing guidelines for coronary angiography[8] have yet to be implemented, and there is little research evidence available about the management of queues for coronary angiography in Canada or elsewhere.[9]

We therefore examined the queuing practices for coronary angiography at a tertiary referral centre to determine clinical and nonclinical determinants of waiting times. We hypothesized that, after illness severity was accounted for, waiting times would be shorter for patients under the care of a specialist practising or catheterizing at the referral centre. We also examined whether any clinical factors, either separately or combined in an urgency rating score, were predictive of an adverse event occurring while patients were waiting in the queue.

Methods

The Sunnybrook site of the Sunnybrook & Women's College Health Sciences Centre provides cardiac catheterization and revascularization procedures to about 15 urban community hospitals and a number of rural centres in central Ontario. Referrals for coronary angiography are generally made directly to the catheterization triage office rather than to an individual interventionalist. At the time of the study less than 50% of the cardiologists at Sunnybrook performed coronary angiography, and these physicians did not maintain individual waiting lists. However, 2 cardiologists who catheterized at Sunnybrook but practised at another centre with no onsite tertiary cardiac capacity (itinerant operators) did maintain lists. The priority assigned to patients was based on written or verbal communication between the cardiologist and a full-time general practitioner who fulfilled the role of catheterization triage officer.

During an 8-week period in the autumn of 1997 a cohort of 378 consecutive patients was booked for a coronary angiography to evaluate coronary artery disease. The study's inception point was the date the triage office was first notified of the patient's referral. Referring physicians, the majority of whom were cardiologists, completed a standardized form for each patient at the time of referral, and a nurse-coordinator and an investigator (D.A.A.) were responsible for patient follow-up and data management. Each patient was followed until a coronary angiography was performed or a fatal event occurred. To minimize intrusion on normal practice, patients in the study were not contacted personally.

Based on the clinical judgement of the triage officer and the referring physician, patients were categorized into 1 of 3 levels of urgency — urgent, semiurgent or elective. The clinical status of each patient on the waiting list was monitored by the triage officer. Itinerant operators used similar implicit triage mechanisms. Physicians working at the same hospital as the itinerant operators could refer patients either directly to Sunnybrook or through their colleagues; their patients were therefore grouped with those of the itinerant operators.

In addition, each patient was retrospectively and independently assigned a formal urgency rating score using criteria established by the Ontario Coronary Angiography Panel.[8] When the information collected did not correspond directly with the determinant variables on the urgency rating scale, or when data were incomplete, point estimates were imputed to reflect an average value between the most- and least-urgent case scenarios.

Fisher's exact test and χ^2 analyses were used to evaluate proportional differences, and Student's *t*-tests were used to compare mean differences in baseline characteristics. Patients who experienced adverse events often had truncated waiting times and were therefore excluded from analyses of waiting-time determinants. Wilcoxon's signed-rank test was used to compare differences between actual and recommended maximum waiting times (RMWT), and a weighted kappa statistic was used to measure the overall agreement between waiting times.

Least-squares regression was used to examine whether clinical factors used in the urgency rating scale predicted actual waiting times. The original urgency rating scale was constructed using regression trees and nonlinear regression because of the number of interactions between clinical factors. Accordingly, clinical factors were examined using the RMWT, or risk score, to circumvent the multiple interactions.

Actual waiting times and RMWTs, stratified by the referring physicians' primary hospital affiliation, were compared using ANOVA. Pair-wise comparisons were done only if the overall analysis was significant ($p < 0.05$). Multiple linear regression was used to determine if physician affiliation predicted waiting time independent of age, sex and risk score.

Kaplan-Meier survival analysis was used to examine event-free survival among patients with different risk scores (RMWT). Risk scores were combined to create 3 groups that paralleled the informal classification used by the cardiac catheterization triage office at Sunnybrook; RMWTs of 1–7 days, 2–6 weeks and more than 6 weeks were assigned to urgent, semiurgent and elective cases, respectively. Patients were censored at the time of coronary angiography.

Adverse events included myocardial infarction, cardiac hospitalization, expedited coronary angiography due to clinical necessity or death. Cox proportional hazards models were utilized to

Table 1: Clinical characteristics of patients referred to Sunnybrook & Women's College Health Sciences Centre for coronary angiography

Clinical characteristic	Physicians' hospital affiliation; no. (and %) of patients		
	Sunnybrook *n = 106*	Itinerant operators *n = 59*	Others *n = 192*
CCS category			
I–II	19 (17.9)	16 (27.1)	51 (26.6)
III	27 (25.5)	23 (39.0)	68 (35.4)
IV-A	13 (12.3)	8 (13.6)	21 (10.9)
IV-B	39 (36.8)	10 (16.9)	45 (23.4)
IV-C	8 (7.5)	2 (3.4)	7 (3.6)
Resting ECG changes (for CCS IV only)			
With pain	17 (28.3)	9 (45.0)	23 (31.5)
Silent	5 (8.3)	0	10 (13.7)
No ECG changes	29 (48.3)	8 (40.0)	29 (39.7)
Data missing	9 (15.0)	3 (15.0)	11 (15.1)
GXT rating			
High risk	22 (20.8)	10 (16.9)	52 (27.1)
Positive	19 (17.9)	21 (35.6)	54 (28.1)
Negative	4 (3.8)	4 (6.8)	24 (12.5)
No test	61 (57.5)	24 (40.7)	62 (32.3)
Nuclear perfusion test rating			
High risk	15 (14.2)	11 (18.6)	46 (24.0)
Not high risk	20 (18.9)	11 (18.6)	73 (38.0)
No test	71 (67.0)	37 (62.7)	73 (38.0)
No. of weeks since myocardial infarction			
< 12	17 (16.0)	15 (25.4)	41 (21.4)
None or > 12	89 (84.0)	44 (74.6)	151 (78.6)
RMWT, days			
0–3	8 (7.5)	2 (3.4)	7 (3.6)
4–7	40 (37.7)	12 (20.3)	45 (23.4)
8–14	5 (4.7)	4 (6.8)	15 (7.8)
15–42	33 (31.1)	12 (20.3)	61 (31.8)
43–91	15 (14.2)	25 (42.4)	46 (24.0)
≥ 92	5 (4.7)	4 (6.8)	18 (9.4)

Note: CCS = Canadian Cardiovascular Society, ECG = electrocardiogram, GXT = graded exercise stress test, RMWT = recommended maximum waiting time.

examine whether baseline variables, in isolation or when aggregated into a composite urgency score, predicted the risk of an adverse event.

This study was approved by the Research Ethics Board at the Sunnybrook & Women's College Health Sciences Centre.

Results

Twenty-one of the 378 patients referred for evaluation of coronary artery disease were removed from the triage list either at the patients' request or because the referring physician felt that the test was no longer indicated. Various clinical characteristics of the remaining 357 patients are characterized in Table 1. The mean age of the cohort was 62.7 years (standard deviation [SD] 11.3, range 32.6–95.7), and 234 (65.5%) of the patients were men. There were no significant age- or sex-related differences between the 3 referral groups.

There were 221 (61.9%) outpatient referrals, 51 (23.1%) of which were made by Sunnybrook physicians; of the 136 (38.1%) inpatient referrals, 55 (40%) were from Sunnybrook. The majority of patients were considered to be in the moderate risk category on the expert panel's urgency rating scale, with a RMWT of 41 days. The RMWT for the inpatient group was 9 days, while that for the outpatient group was 49 days ($p < 0.001$).

Precise estimates or minimal ranges in urgency scores (i.e., most- to least-urgent-case scenario < 1) were calculated for 274 (72.5%) of the patients. Treadmill testing resulted in the most scoring uncertainty, probably because the original low- and moderate-risk groups were amalgamated and because physicians likely did not refer highly symptomatic patients for treadmill testing. We found no significant differences between referral groups in patient acuity, as estimated from the urgency rating scale.

There was moderate agreement between actual waiting times and RMWTs for coronary angiography (Table 2); the weighted kappa statistic was 0.53. Patients, on average, waited longer than their RMWT ($p = 0.01$), but this was largely because of excessive delays for the less-urgent patients.

Median RMWT and actual waiting times for angiography, stratified by clinical characteristics, are compared in Table 3. Clinical factors incorporated in the risk scores accounted for 45.6% of the variability in actual waiting times ($p < 0.001$). Age and sex were not significant predictors in a multivariate model that included the risk score.

In Table 4 mean waiting times are presented for each physician group for both inpatients and outpatients. Although patient acuity did not vary significantly across the 3 groups for hospitalized or nonhospitalized patients, significantly shorter waiting times were observed for inpatients from Sunnybrook than for the inpatients referred by the "other" physicians (mean 1 day v. 8 days, $p < 0.001$). The shortest waiting times for outpatients were for those managed by itinerant operators (28.6 days); outpatients of the Sunnybrook and "other" physicians waited an average of 58.5 and 85.2 days, respectively ($p < 0.001$ for all 3 pair-wise comparisons).

In-hospital status and physician affiliation remained significant independent predictors of actual waiting time even after adjusting for patient age, sex and risk score (i.e., Sunnybrook v. "other" inpatients, $p < 0.001$; itinerant operators and Sunnybrook outpatients v. "other" outpatients, both $p < 0.001$). A significantly greater amount of variation in actual waiting times could be explained when physician referral group was considered; 45.6% of the variation was explained by age, sex and risk score, whereas 54.9% of the variation was explained by age, sex, risk score and physician referral group. Thus, 9.3% of the variation was explained by physician affiliation alone.

Twenty-two (6.2%) patients experienced adverse clinical events; changes in the symptom status of 16 (72.7%) of these patients necessitated expedited coronary angiography, and half of these patients required urgent hospitalization. Four patients died and 2 experienced acute myocardial infarction during the study. No significant differences were found in clinical factors or aggregated scores between patients who experienced adverse events and those who did not. The event-free survival was similar across the 3 strata of acuity defined by the urgency rating scale (the proportions were 0.95 [stan-

Table 2: Recommended maximum waiting times (RMWTs) and actual waiting times (AWTs) for patients who did not experience an adverse event*

	AWT, days						No. (and %) of patients receiving angiography within RMWT
RMWT, days	0–3	4–7	8–14	15–42	43–91	≥ 92†	
0–3	**9**	3	3	0	0	0	9 (60.0)
4–7	44	**31**	17	3	0	0	75 (78.9)
8–14	7	4	**5**	3	3	0	16 (72.7)
15–42	7	7	10	**35**	18	19	59 (61.5)
43–91	0	0	12	17	**13**	38	42 (52.5)
≥ 92†	0	1	0	4	2	**20**	–
Total	67	46	47	62	36	77	201 (60.0)

*Bold values indicate a match between AWT and RMWT. Values underlined indicate patients for whom AWTs were 1 or more categories beyond that recommended on the basis of their clinical profile.
†Patients for whom no urgent need was detected.

dard error of the mean (SEM) 0.03], 0.90 [SEM 0.03] and 0.93 [SEM 0.03] for RMWTs of 1–7 days, 2–6 weeks and > 6 weeks, respectively; log-rank χ^2 statistic 3.72, $p = 0.16$). Event-free survival statistics for the implicit triage categories assigned by Sunnybrook were also similar across groups (the proportions were 0.93 [SEM 0.04], 0.86 [SEM 0.04] and 0.93 [SEM 0.03] for urgent, semiurgent and elective risk categories, respectively; log-rank χ^2 statistic 2.17, $p = 0.34$).

Interpretation

In this single-centre study informal waiting-list management practices for cardiac catheterization used and weighted clinical factors in a fashion similar to that recommended by an expert panel.[8] Even in the absence of a formal queue management system, physicians seek to protect patients by ensuring shorter waiting times for those with more severe symptoms or at higher risk of adverse events. Accordingly, our findings are consistent with procedures followed for patients waiting for coronary artery bypass surgery and with the results of at least 1 coronary angiography study.[9]

Nonclinical factors, such as referring physicians' ties to cardiac catheterization facilities, significantly influenced the actual waiting time for patients in this study. Despite equivalent urgency, Sunnybrook inpatients had significantly shorter waits than patients in other hospitals waiting for coronary angiography. Waiting-time discrepancies were not as obvious for outpatients, but patients referred by physicians with the closest affiliation to the triage centre consistently had shorter waits. Moreover, of the outpatients, those referred by community physicians with catheterization privileges at Sunnybrook spent the shortest amount of time in the angiography queue. These findings are consistent with other observational studies indicating that accessibility and resource availability correspond to higher rates and shorter waiting times for invasive cardiac procedures.[10–13] The results are also consistent with the procedures followed for bypass surgery patients in Ontario before the implementation of a formal waiting-list management system;[7] an audit based on health care practices in the late 1980s found that implicit triage mechanisms discriminated against patients in institutions that had no onsite revascularization facilities.

The reasons for the variations in waiting times were not examined. However, the discrepancies we found are inconsistent with the principle of equal waiting times for patients of similar clinical acuity, where cumulative symptomatic burdens or risks of adverse events are levelled out across acuity strata. There were no differences in event-free survival for the patients in the different acuity strata in our study, but the sample was too small for strong inferences to be drawn about the relation between queuing practices and adverse events. Approximately 1800 patients would have been required to detect and label significant interstrata differences of the magnitude seen in this study (absolute differences of 3% between groups). An assessment of queuing practices and the validation of any proposed urgency rating scale also require that other adverse outcomes, such as im-

Table 3: Median AWT and RMWT, stratified by clinical characteristics

Clinical characteristic	No. (and %) of patients	Median AWT (and Q1–Q3*), days	Median RMWT (and Q1–Q3*), days
CCS category			
I–II	86 (24.1)	113 (36–120)	68 (50–98)
III	118 (33.1)	37 (16–116)	39 (24–49)
IV-A	42 (11.8)	10 (2–35)	12 (8–19)
IV-B	94 (26.3)	3 (1–6)	5 (4–6)
IV-C	17 (4.8)	1 (0–6)	2 (2–2)
GXT rating			
High risk	84 (23.5)	34 (6–56)	17 (7–31)
Positive	94 (26.3)	66 (11–120)	49 (36–67)
Negative	32 (9.0)	35 (9–121)	76 (6–106)
No test	147 (41.2)	6 (1–21)	6 (4–39)
Nuclear perfusion test			
High risk	72 (20.2)	36 (8–65)	17 (13–42)
Not high risk	104 (29.1)	52 (13–120)	67 (26–95)
No test	181 (50.7)	7 (1–29)	10 (5–39)
No. of weeks since myocardial infarction			
< 12	73 (20.4)	5 (1–10)	6 (4–13)
None or > 12	284 (79.6)	32 (6–115)	38 (8–64)

*Q1–Q3 = 25th percentile to 75th percentile.

Table 4: Mean waiting times by affiliation of referring physician for inpatients and outpatients who did not experience an adverse event

Patient group	Mean waiting time, no. of days (and 95% CI)			
	Sunnybrook	Itinerant operators	Other	*p* value
Inpatient referrals				
AWT	1.0 (0.7–1.3)	5.7 (3.2–8.1)	8.0 (4.1–11.9)	0.003
RMWT	8.2 (5.7–10.8)	4.6 (3.6–5.6)	10.4 (6.0–14.8)	0.4
Outpatient referrals				
AWT	58.5 (46.2–70.8)	28.6 (18.8–38.4)	85.2 (76.9–93.5)	< 0.001
RMWT	45.4 (38.2–52.6)	48.4 (40.6–56.2)	52.4 (46.9–57.9)	0.3

Note: CI = confidence interval.

pairment of quality of life, time off work and burden on relatives, be measured.

The generalizability of these results to other institutions and patient populations is uncertain. Not all hospitals have a single-access queue for the majority of coronary angiography patients, and queuing practices may vary across hospitals. However, we believe it is unlikely that, in the absence of formal measurement and management, queuing practices elsewhere are more consistent than those observed in this study.

In conclusion, this study sheds new light on queuing practices for coronary angiography. Although informal implicit management systems respond to measures of clinical burden and risk that are similar to those incorporated in explicit urgency scales, angiography waiting lists are also influenced by nonclinical factors such as where the patient is hospitalized, as well as the nature of the referring physician's link to the cardiac catheterization facilitiy. These inequities in the waiting time for the delivery of cardiac procedures reinforce the need to implement queue-management systems to help ensure that all patients in need receive service in a timely and fair fashion.

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