Second reading of coronary angiograms by radiologists

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BACKGROUND: In many hospitals in the provinces of Quebec and Nova Scotia, as well as in some hospitals in the rest of Canada, coronary angiograms are performed and interpreted by invasive cardiologists, and are later reinterpreted and reported by radiologists.
OBJECTIVE: To evaluate the value of second readings of coronary angiograms by radiologists.
METHODS: Cardiology and radiology reports of a total of 160 consecutive coronary angiograms were compared from patients at three hospitals. Ten segments of the coronary tree were considered and 1582 segments were included. Agreement between cardiology and radiology interpretations was evaluated using per cent agreement, Pearson correlation and Bland-Altman limits of agreement. Agreement was calculated for each arterial segment and for each hospital.
RESULTS: Excellent agreement was found between cardiology and radiology interpretations of coronary angiograms. Per cent agreement ranged from 94.9% to 100%, Pearson correlation ranged from 0.83 to 0.97 and Bland-Altman limits of agreement ranged from –18.1 to 19.4. Agreement was similar for each segment and for each hospital. Agreement remained excellent after exclusion of normal angiograms (n=348 segments), with a per cent agreement of 96.3%. Secondary analyses demonstrated a mean time delay of 13 days between angiograms and the subsequent radiology reports.
CONCLUSIONS: There are minimal differences between the cardiology and radiology interpretations of coronary angiograms. Routine second reading by a radiologist may be redundant.

Key Words: *Coronary angiography; Inter-interpreter agreement; Radiography*

Une deuxième lecture des angiogrammes coronaires par les radiologues

HISTORIQUE : Dans de nombreux hôpitaux des provinces de Québec et de Nouvelle-Écosse, ainsi que dans certains hôpitaux du reste du Canada, les angiogrammes coronaires sont effectués et interprétés par des cardiologues effractifs, puis interprétés de nouveau par des radiologues.
OBJECTIF : Évaluer la valeur de la deuxième lecture des angiogrammes coronaires par les radiologues.
MÉTHODOLOGIE : On a comparé les rapports de cardiologie et de radiologie de 160 angiogrammes coronaires consécutifs chez des patients de trois hôpitaux. Dix segments de l'arbre coronaire ont été pris en compte, et 1 582 segments ont été inclus. On a évalué la concordance entre l'interprétation cardiologique et radiologique au moyen du degré de concordance, de la corrélation de Pearson et des limites de concordance de Bland-Altman. On a calculé la concordance de chaque segment artériel et de chaque hôpital.
RÉSULTATS : On a constaté une excellente concordance entre les interprétations cardiologique et radiologique des angiogrammes coronaires. Le degré de concordance oscillait entre 94,9 % et 100 %, la corrélation de Pearson, entre 0,83 et 0,97 et les limites de concordance de Bland-Altman, entre –18,1 et 19,4. La concordance était similaire pour chaque segment et chaque hôpital. Elle demeurait excellente après l'exclusion des angiogrammes normaux (n = 348 segments), le degré de concordance s'élevant alors à 96,3 %. Les analyses secondaires ont démontré un retard temporisé de 13 jours entre les angiogrammes et les rapports radiologiques subséquents.
CONCLUSIONS : On remarque des différences minimes entre les interprétations cardiologique et radiologique des angiogrammes coronaires. La deuxième lecture systématique par les radiologues pourrait être redondante.

The number of coronary angiograms performed each year in Canada is substantial. In Ontario alone, more than 100,000 coronary angiograms are performed each year (1). Angiograms are generally performed and interpreted by invasive cardiologists. However, in some hospitals, coronary angiograms are performed by invasive cardiologists, and are later reinterpreted and reported by radiologists. Although this practice of second reading has been abandoned by hospitals in many provinces, it continues regularly in the provinces of Quebec and Nova Scotia, as well as in some hospitals in the rest of Canada (Canadian Association of Radiologists, personal communication). Second readings significantly increase health care costs. In Quebec, for example, more than one million dollars is spent each year on remuneration to radiologists for the interpretation and reporting of coronary angiograms (2,3). Considering the additional costs associated with second readings of angiograms, routine second readings should be evaluated. In particular, in an era of percutaneous coronary interventions (PCI), when decisions regarding patient management are almost always made and implemented at the time of the angiogram, the necessity of second, delayed readings should be assessed. Although many studies have examined the inter-interpreter agreement of angiographic readings (4-13), little is known about the usefulness of routine second reading by radiologists. The objective of the present study was to evaluate the value of routine second reading of coronary angiograms by radiologists.

METHODS

Selection of angiograms

A total of 160 coronary angiograms from three hospitals were examined. Angiograms were identified from the coronary

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TABLE 1
Distribution of coronary disease among 160 coronary angiograms

Radiologist interpretation	Cardiologist interpretation			
	Normal	Single-vessel	Double-vessel	Triple-vessel
Normal	38	2	0	0
Single-vessel	0	45	0	0
Double-vessel	0	0	37	2
Triple-vessel	0	0	0	36

A vessel was considered diseased when any of its corresponding arteries contained significant (≥50%) stenosis. Single-vessel disease corresponds to significant stenosis in any one of the three major epicardial arteries. Double-vessel disease corresponds to stenosis in two of the major epicardial arteries or of the left main artery and triple-vessel disease corresponds to stenosis in all three major epicardial arteries. In 156 of 160 angiograms, both specialists agreed on the number of diseased arteries. In four angiograms in which the specialists disagreed on the number of diseased vessels, the cardiologist identified a segment as diseased that was not identified as such by the radiologist. In one angiogram, the cardiologist identified a left main artery as significantly stenosed, but the artery was not mentioned in the radiology report and was thus assumed to have no stenosis. In the three other angiograms in which the specialists disagreed, the cardiologist thought a segment was 50% stenotic, while the radiologist thought it was 40% stenotic (proximal right coronary artery and middle left anterior descending artery) or 30% stenotic (distal right coronary artery)

catheterization laboratory log books that record all angiograms performed. Fifty to 60 consecutive angiograms from each hospital were examined, beginning on three arbitrary dates in 2001 (January 1, September 1 and December 1). When multiple angiograms from a single patient were available (n=2), all angiograms were included. Angiograms were excluded if a report was missing, insufficiently completed or illegible (n=23). Angiograms of patients with previous coronary bypass surgery were also excluded (n=37). Ethics approval for this study was obtained from the McGill Faculty of Medicine Research Ethics Board (Montreal, Quebec).

Interpretation of angiograms

The cardiology and radiology reports for each angiogram were reviewed. A study investigator who was not involved in patient management reviewed each report. Reports from 10 cardiologists and five radiologists were examined. For each angiogram, 10 segments of the coronary tree were considered, so 1600 segments were potentially available for analysis. These segments were the proximal, middle and distal portions of the right coronary artery (RCA), the left anterior descending coronary artery (LAD) and the circumflex coronary artery, as well as the left main coronary artery (LM). These 10 segments correspond to the major epicardial arteries, not including branch arteries. Branch arteries were not included in the present study because reporting on branch vessels was inconsistent in the study's angiogram sample. The organization of arterial segments was in keeping with models used in previous studies (11). In eight angiograms, radiologists used descriptive words instead of percentages to describe the degree of arterial narrowing in some segments. These segments (n=18) were excluded from agreement analyses, so a total of 1582 segments was included in the final analyses.

Statistical analysis

The primary analysis consisted of two phases: the descriptive phase and the analytic phase. In the descriptive phase, the extent of coronary disease was evaluated. An artery was considered diseased when any of its corresponding segments contained significant (at least 50%) stenosis. Single-vessel disease corresponds to significant stenosis in any one of the major epicardial arteries: the RCA, the LAD or the circumflex coronary artery. Double-vessel disease corresponds to stenosis in two of the major epicardial arteries or of the LM and triple-vessel disease corresponds to stenosis in all three of the major epicardial arteries. In the descriptive phase, reports that used words instead of percentages to describe arterial lumen calibre were included (n=8 angiograms), and words were converted into estimations of per cent stenosis. For example, arterial segments that were described as 'patent' or 'mild' were included as 50% stenosis or less, whereas segments described as 'significant' or 'severe' were included as greater than 50% stenosis. In the descriptive phase, the possible tendency of one specialist over- or under-rating stenosis severity was also explored. For these analyses, segments deemed significantly stenosed by one specialist were reviewed to evaluate whether the other specialist had also identified the presence of a significant stenosis.

The second phase of the primary analysis, the analytic phase, evaluated the agreement between cardiology and radiology interpretations of 1582 coronary segments. Measures of agreement included per cent agreement, Pearson correlation and Bland-Altman limits of agreement. The per cent agreement represents the proportion of arterial segments on which both readers agreed as to the presence or absence of stenosis. Per cent agreement was calculated for two thresholds. The threshold defines the degree of arterial lumen narrowing to be considered stenotic. For a given threshold, any reading above this value is considered stenotic and any one below is considered nonstenotic. Any two readings above or below the threshold were considered to agree, whereas one reading below the threshold and one reading above the threshold were not. A primary threshold of 50% and a secondary threshold of 75% were used for analysis in the present study. Pearson correlations were calculated to investigate the strength of the relation between cardiology and radiology reports. Agreement between cardiologist and radiologist interpretations were also examined using Bland-Altman limits of agreement. Bland-Altman limits of agreement measure the mean difference between two values while incorporating uncertainty, or random error (14). It can be interpreted as a CI of the difference. The primary analyses were calculated for each segment of the coronary tree and for each hospital. Analyses were repeated for abnormal angiograms alone, where abnormal was defined as stenosis greater than zero on either the cardiology or radiology report, such that entirely normal angiograms were excluded.

The secondary analysis consisted of a review of angiograms from patients in whom a percutaneous intervention was performed at the time of the angiogram to determine whether the second reader had agreed to the presence of a significantly (at least 50%) stenosed artery. Finally, the dates of the angiogram, the cardiology and radiology reports were examined. The date of the angiogram was compared with the date of each report to determine the time delay between the angiogram and subsequent reports.

RESULTS

Extent of coronary disease

In the study sample of 160 coronary angiograms, both readers agreed on the number of diseased vessels in 98% of cases (156 of 160). Among the 156 angiograms, 38 were normal, 45 had single-vessel disease, 37 had double-vessel disease and 36 had triple-vessel disease (Table 1). In four angiograms in which the specialists disagreed as to the number of diseased