Efficiency and Cost Saving of 7 Day Per Week Exercise Testing Utilizing All Electrocardiography Technologists

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Background: In most centers, exercise testing (ET) is performed by one or two trained technologists during the weekdays (0800 hours-1600 hours), leaving a void during evenings and weekends. This leads to unnecessary increased costs due to delays in management of patients. Electrocardiography technologists (ECGT) are often available for extended hours. This project was undertaken to improve the efficiency of the ET laboratory by using ECGT to perform ET during these extended hours.

Methods: Clinical utility and cost saving of a 7 day per week ET for management of patients with suspected and/or known coronary artery disease utilizing ECGT was assessed after adequate training. Of 4099 patients undergoing ET between January 1995 and December 1997, 810 tests performed by ECGT were reviewed retrospectively.

Results: Of the 810 patients (age mean 58.4 ± 0.44 yrs; range 16-88; males: 508, females: 302), 806 (99.5%) underwent the Bruce protocol. The indications were: diagnostic, 61.3%, predischARGE acute myocardial infarction (AMI), 17.7%, evaluation of angina, 19.6%, other, 1.4%. Only 8 (0.1%) patients had complications (prolonged chest pain, 6; nonsustained ventricular tachycardia, 2) with no AMIs or deaths. This strategy resulted in a savings of 158 bed days (Can\$189,600) on inpatients and 15 bed days (Can\$18,000) on those presenting to the emergency department.

Conclusions: This study demonstrates the feasibility and safety of utilizing ECGT for ET thus extending the hours of service. This resulted in efficient patient management, with a considerable cost-saving to the hospital.

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Chest pain is a frequent presenting symptom in patients seeking treatment in emergency departments.¹ Early assessment and diagnosis using exercise tests (ET) may minimize inappropriate use of hospital beds, as admissions may be avoided if patients are found to have a normal exercise test. Furthermore, patients in the early phase of recovery after an acute myocardial infarction (AMI), as well as those who have been treated for unstable angina, often need assessment through ET prior to discharge for prognostification and to provide in-

formation on their ability to return to moderate levels of physical activity.² In both these groups of patients, ET needs to be done in a timely and cost-effective manner with the requests for these tests accepted and completed 7 days a week. In this institution as well as many others, one or two appropriately trained personnel, either nurses or technologists, are assigned to perform all ET done in the hospital in association with the physician(s). This is in keeping with the recently published guidelines for exercise testing.³ These primary per-

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sonnel performing ET are only available during 0800-1600 hours on weekdays, thus leaving a void during the evening hours and during weekends and statutory holidays. In contrast, ECG technologists (ECGT) who have been assigned to provide the 12-lead ECG service within institutions, generally work on shifts with service commencing earlier in the day and often extending to the late evening hours. Further, they are available on the weekends as well as on statutory holidays.

The present study was undertaken to assess the safety, feasibility, and cost consequences of utilizing all ECGT to provide the required ET during these extended hours.

METHODS

The ECGT responsible for the provision of electrocardiographic services at this institution underwent a cross training program which included technical aspects of ET and all issues related to patient safety. All ET were performed under the supervision of a physician (as was the situation with the primary personnel doing ET). The initial training was done by the primary personnel responsible for ET in association with the physicians. The competencies attained included blood pressure measurement and the ability to recognize electrocardiographic and/or clinical signs and symptoms during and after the test which may require modification of the protocol and/or post test management. The ECGT were trained to become skilled in selecting relevant data and interpreting and communicating the results to the attending physician(s). All ECGT at this institution were required to have current certification in Basic Life Support (this was not necessitated by their participation in ET).

In this institution, the primary personnel performing ET are available from 0800 to 1600 hours on weekdays. However, four additional ECGT are available to provide the ECG service from 0700 to 2200 hours on weekdays and 0900 to 2100 hours on weekends and statutory holidays.

The study population consisted of a retrospective review of 810 patients who underwent ET by the ECGT during a two-year period. The patient population were from three sources: (1) inpatients who required ET prior to discharge; (2) patients who presented to the emergency department where ET was considered necessary for appropriate triage; (3) outpatients scheduled for ET (this group was

done during the training period and when the primary technologist was on leave).

All patients had ET using an automated system (model # Q5000, Quinton Instruments Company, Bothell, Wa, USA 98021-8906). The ECG (12 leads) was recorded using the lead system described by Mason and Likar.⁴ A 12-lead ECG was recorded before exercise, at the end of each stage of exercise, at maximum exercise and 1 minute, 2 minutes, and 4 minutes after completion of the exercise. Leads V3, V5, and aVF were monitored continuously with the magnitude of ST-segment depression measured 80 ms after the J-point and the ST-segment slope were analyzed. Horizontal or downsloping ST depression of > 0.1 mv observed in three consecutive beats was considered a positive test. The Bruce protocol was used as the preferred method wherever possible (i.e., 99.5% of the patients). The test was carried out to maximum effort in the absence of any of the following: (1) horizontal or downsloping ST depression in excess of 0.4 mv (test terminated before this in some instances in the presence of concomitant typical angina-type chest pain associated with horizontal or downsloping ST depression > 0.1 mv); (2) fall in systolic BP of > 10 mmHg accompanied by symptoms of lightheadedness; (3) sustained or frequent runs of nonsustained ventricular tachycardia; (4) as requested by the patient. The physician was present in the ET room (as is the practice in all ETs done at this institution) and made the decisions with regard to the timing of termination of the ET and provided the final interpretation of the test. This is the standard of practice at this institution and not necessitated by the present study. There were 4 physicians (3 cardiologists and 1 internist) who did all the ETs at this institution. Each of these individuals had over 10 years experience in ET and performed > 300 studies per year.

The ET were done in the Electrodiagnostics department of the hospital. A cardiac arrest supply cart together with a defibrillator was available in the same room to be utilized by the attending physician if necessary. The site of ET and the supplies available remained unchanged for the ET performed by the ECGT. Further, no other additional personnel (e.g., registered nurses) were made available for the ETs done after hours and on weekends (i.e., only the attending physician and the ECGT were present in the room in addition to the patient). The Grey Nuns Hospital is an acute care institution with a cardiac arrest team available to

respond to any cardiac arrest within the exercise testing area. The results of the ET were tabulated as being positive, negative, or indeterminate and complications related to the test were recorded.

Statistical Analysis

All data were entered into a database formulated within the SPSS database management system with all statistical analyses performed utilizing this system.⁵ Continuous variables were entered as such, and discrete variables were formulated to ensure that the categories within one variable were mutually exclusive.

Cost Analysis

A cost analysis was done utilizing the bed days saved as a result of an early discharge from the hospital or avoiding an admission in the case of patients presenting to the emergency room. In the event of a predischage ET performed on a Sunday or statutory holiday, it was deemed that a cost saving of one bed day was realized. In the case of an ET being done on a Saturday it was deemed that a cost savings of two bed days were realized. This was done on the basis of the fact that prior to the implementation of this management strategy, patients were kept in hospital until the next working day whenever it was felt that discharge without doing an ET was not appropriate. Further, in these patients in whom a decision was made to proceed with other investigations (e.g., coronary angiography) following the ET, doing the test on weekends or statutory holidays enabled these investigations to be booked and completed early, resulting in a reduction in the total duration of hospital stay. On patients presenting to the emergency room who were discharged following the ET, similar savings were realized as they were often admitted and kept over night for observation in the absence of an immediate availability of ET. The costs for the hospital bed days were obtained from the hospital finance department and was the per diem charge for noninsured patients (patients covered under the Alberta Government Health Care Insurance Plan do not incur any direct costs). The cost of a bed day was Can\$1200.00. The capital costs for training the ECGT was calculated at \$20.00 per hour (note: 1.0 Can\$ = 0.68 US\$). There was no increase in the salary of the ECGT based on their participation in ET on an as-needed basis as utilized in the study

(salary increases were based on the years of service). There were no additional costs incurred based on physician supervision of ET as this was the standard care of practice at the institution as outlined previously.

RESULTS

Between the period of January 1995 and December 1997, a total of 4099 patients underwent ET at this institution. Of these, 810 (19.8%) were performed by the nonprimary ECGT and included in the present study. There were 184 (23%) in-patients and 626 (77%) out-patients. One hundred and sixty-one (20%) tests were performed during extended hours. The remaining 649 ET were performed during the absence of the primary technologist, when away for reasons of sick leave, vacation, or other scheduled breaks. The demographics and ET results on these 810 patients are tabulated in Table 1. There were 508 males and 302 females: age mean 58.4 ± 0.44 year; range 16-88 years. The indications for ET were: diagnostic evaluation of chest pain in 61.3%, predischage post AMI in 17.7%, evaluation of angina in 19.6%, and other in 1.4%. The Bruce protocol was used in 806 (99.5%) of the patients. The duration of exercise was mean 8.1 ± 0.2 minutes (range 0.33-20 minutes) together with a maximum heart rate attained of mean 140 ± 1.0 beats/min (range 69-196 beats/min). The maximum heart rate achieved as a percentage of the maximum predicted heart rate was mean $90.4 \pm 5.6\%$ for diagnostic tests. Of the 810 tests, 471 (58.1%) were negative, 230 (23.1%) were positive

Table 1. Demographics and Other Clinical Characteristics of the Patient Population (n = 810)

	Male	Female
No. of patients	508 (62.7%)	302 (37.3%)
Age (yr)	56.9 ± 0.6	60.8 ± 0.7
Range (yr)	16-87 y	16-88 y
<50	162 (32%)	60 (20%)
50-70	270 (53%)	173 (57%)
>70	76 (15%)	69 (23%)
Source		
Outpatient	341 (67%)	227 (75%)
Inpatient	130 (26%)	54 (18%)
Emergency department	37 (7%)	21 (7%)

Number of patients with the percentages from within that group (males vs females) are tabulated.

Table 2. Results and Complications of the Exercise Tests in the Patient Population (n = 810)

	Male	Female
No. of patients	508 (62.7%)	302 (37.3%)
Diagnostic group	206 (40.6%)	162 (53.6%)
Positive	29 (14.1%)	30 (18.5%)
Negative	151 (73.3%)	103 (63.5%)
Indeterminate	26 (12.6%)	29 (18%)
Duration of ET	9.4 ± 0.2 m	7.1 ± 0.2 m*
Range	1.3–20 m	0.33–15 m
Predicted maximum HR (beat/m)	164 ± 1	159 ± 1*
Maximum HR achieved (beat/m)	152 ± 2	144 ± 2*
Coronary artery disease group	302 (59.4%)	140 (46.4%)
Positive	93 (30.8%)	35 (25.0%)
Negative	180 (59.6%)	80 (57.1%)
Indeterminate	29 (9.6%)	25 (17.9%)*
Duration of ET	8.4 ± 0.2 m	6.6 ± 0.2 m*
Range	2.3–17.3 m	1.2–17.3 m*
Predicted maximum HR (beat/m)	162 ± 1	159 ± 1*
Maximum HR achieved (beat/m)	134 ± 1	132 ± 2
Complications		
Deaths, cardiac arrest, AMI	0 (0.0%)	0 (0.0%)
Prolonged chest pain	6 (1.2%)	0 (0.0%)
Nonsustained VT	2 (0.4%)	0 (0.0%)
Other	1 (0.2%)	0 (0.0%)

Number of patients with the percentages from within that group (males vs females) or mean (SEM) are tabulated. HR = heart rate; ET = exercise test; AMI = acute myocardial infarction; VT = ventricular tachycardia.

* P < 0.05.

(male = 144, female = 86), and 109 considered indeterminate (Table 2).

The following complications related to the ET: in six patients prolonged chest pain (defined as chest pain lasting more than 5 minutes after termination of the test but with no resultant adverse outcome); nonsustained ventricular tachycardia without adverse outcomes in two patients. There were no AMIs, cardiac arrests, syncope, sustained ventricular tachycardia, or deaths related to the test. Of the 184 in-patients who underwent ET, 68 were positive, 97 negative, and 19 considered indeterminate. Seventy-six of these patients were discharged home the same day, with 42 patients discharged the next day. Of the 58 patients from the ER who had ET, 17 were positive, 32 negative, and 5 considered indeterminate. Following the ET, 44 patients were discharged home with 14 admitted to the coronary care/intermediate care unit.

Cost Analysis

As a result of the ET being carried out on Saturdays, Sundays or statutory holidays, early dis-

charge was achieved in 113 in-patients representing 158 saved bed days. This resulted in a cost saving of Can\$189,600.00. In addition, 15 bed days at a cost of Can\$18,000.00 were saved on patients presenting to the emergency department where the availability of ET after regular working hours resulted in avoidance of admission. Thus the total cost saving was Can\$207,600.00 which amounted to a mean saving of Can\$256.00 per patient. Although 161 ETs were done during extended hours, cost savings were realized in only 113 in-patients and 15 out-patients presenting to the emergency department. The rest of the patients could not be discharged sooner as the results of the ET dictated further management steps (e.g., arranging coronary angiography for in-patients with a positive ET). Each ECGT underwent approximately 20 hours of training. The capital cost for the training of four ECGT was Can\$1,600.00. Taking this into consideration the net cost saving was Can\$206,000.00 (for 2 years) or Can\$103,000.00 per year (approximately US\$70,040.00 per year).

DISCUSSION

During the past few years, there has been a significant reduction in budgets allocated to health care expenditure in Canada.⁶ This has been as a result of the increasing cost of health care with governments under pressure to balance their budgets. These reductions in the budgets have resulted in increased waiting time for many investigations, such as coronary angiography, coronary artery bypass surgery, whenever the indication is not deemed an emergency. Nevertheless, the forced reduction in the allocated budgets has brought about many beneficial changes in health care utilization, improving efficiency while minimizing waste and inappropriate management. Several innovative programs using Home Care with community nurses have enabled the durations of in-hospital stay of patients with acute illnesses to be reduced without any significant adverse outcome.

In spite of all these changes that have occurred within health care institutions to improve the efficiency of service, many patients have their in-hospital or emergency stays extended in view of the lack of availability of diagnostic procedures in Canada. Traditionally many investigations and procedures are done in health care institutions during working hours from Monday to Friday. This leaves over two-thirds of each day, as well as all weekends and statutory holidays, as times when only urgent and emergency procedures are done. However, if efficient management of beds is to be achieved to minimize costs, the needs of the patients cannot be deemed as ending at 4:00 P.M. each day and be nonexistent during the weekends. In view of the above limitations, a number of patients are kept in hospital or in the emergency departments, as physicians feel uncomfortable in sending these patients home without one or more appropriate investigations. Two common examples are patients with cardiovascular diseases who: (1) are admitted with acute coronary syndromes to the coronary care unit where a predischarge ET is deemed necessary; (2) present to the department with chest pain with no obvious diagnosis, where doing an ET prior to patient triage is deemed necessary. The limitation in these instances appears to be the unavailability of ET outside the usual working hours. The present study has looked at the feasibility of minimizing this problem with better patient management, as well as accomplishing optimum utilization of hospital resources by training

all ECGTs to do ET in association with the physicians involved. The training was achieved with a minimum of additional cost as it was done during their regular working hours, with the only cost being two technologists instead of one attending the ET during the training period. This amounted to 15-20 tests for each trainee ECGT with an estimated cost of Can\$400.00 per trainee. Further, this expenditure will be a one time capital cost for each ECGT with no recurrent costs expected (as long as each ECGT continues to perform a sufficient number of ETs on an ongoing basis). Following this, the tests were carried out by the ECGT as required.

A concern existed that having too many ECGTs doing ETs would result in a suboptimal level of competence, which could potentially lead to a lack of confidence on the part of the technologists. If this were to occur, the safety of the patients could be compromised. Further, a higher incidence indeterminate ET could occur as a result of terminating the tests too early. The present study demonstrated that the safety was not compromised during 810 ETs performed by the nonprimary ECGTs. Further, there were no major complications and few minor complications. For diagnostic tests, the adequacy of the ET was confirmed by the maximum heart rate achieved as a percentage of the maximum predicted heart rate being mean 90.4 (5.6)%. Only diagnostic tests were utilized in this calculation as the maximum heart rate achieved was often blunted in those with coronary artery disease in view of concomitant use of beta-blockers.

The present management strategy also is an advantage for patients, minimizing the frustration in having to stay in-hospital for only the procedure without any other need for continuing hospital care. In-hospital care also exerts strains on family and relatives who often have to take time off to attend to the needs of patients.

The present strategy also resulted in considerable cost savings. The limitation of the cost analysis is the assumption that the patients would be kept in hospital or admitted until the next working day if immediate ET was not available. It is likely that some patients could have been discharged based on the clinical judgement of the cardiologist with the ET booked at a later date with the patient returning as an outpatient. However, historical reviews at this institution have confirmed that the majority of such patients were held back in hospital or admitted until the ETs were completed. The availability of ET during weekends and statutory holidays has

been one factor that has enabled this institution to decrease the mean in-hospital stay for acute myocardial infarctions from 11.8 days during the period of 1989-1992 compared to mean 5.1 ± 0.2 days for the period 1995-1997 as shown in a previous study.⁷ Further, cost saving as a result of the early ET of patients who present with chest pain to the department has also resulted in a significant decrease in the number of patients who have been admitted at this institution for the purpose of exclusion of angina in the etiology of the presenting chest pain.⁸ During the past three years, only 4.0% of the total admissions to the coronary care unit had a discharge diagnosis of noncardiac chest pain. Further, 21.7% and 34.8% of the total number of admissions had a discharge diagnosis of unstable angina and acute myocardial infarction, respectively.⁷ This is in contrast to the less than 20% rate of a final diagnosis of acute myocardial infarction on those admitted with chest pain to a coronary care unit as quoted in a recent review.¹

The present study demonstrates that considerable improvement in efficiency, with consequent reduction in cost, could be achieved by utilizing all ECGT to do ET within the institution without compromising the safety and adequacy of the investi-

gation. This change can be accomplished at all institutions where a sufficient number of ETs are done to ensure that each ECGT would be able to do an adequate number of ETs in an ongoing manner to maintain skill and competence.

REFERENCES

1. Jesse RL, Kontos MC. Evaluation of chest pain in the emergency department. *Curr Prob Cardiol* 1997;22:151-236.
2. Senaratne MPJ, Hsu L, Rossall RE, et al. Exercise testing after myocardial infarction: Relative value of the low level pre-discharge and the postdischarge exercise test. *J Am Coll Cardiol* 1988;12:1416-1422.
3. Gibbons RJ, Balady GJ, Beasley JW, et al. ACC/AHA guidelines for exercise testing: A report of the American College of Cardiology/American Heart Association Task Force on Practice. *J Am Coll Cardiol* 1997;30:260-315.
4. Mason RE, Likar I. A new system of multiple-lead exercise electrocardiography. *Am Heart J* 1966;71:196-205.
5. Norusis MJ. Data Files. In *SPSS for Windows: Base system user's guide*. Release 6.0. Chicago, SPSS Inc. 1993;27-54.
6. Canadian Institution for Health Information: National health expenditure trends 1975-1997. 1997; 21-27.
7. Senaratne MPJ, Irwin ME, Shaben S, et al. Feasibility of direct discharge from the coronary/intermediate care unit after acute myocardial infarction. *J Am Coll Cardiol* 1999; 33: 1040-1046.
8. Senaratne MPJ, Carter D, Irwin ME. Adequacy of an exercise test in excluding angina on patients presenting to the emergency department with chest pain. *Ann Noninvasive Electrocardiol* 1999;4:408-415.