Training/Practice: Training

Electrocardiographic Interpretation Skills of Cardiology Residents: Are They Competent?

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ABSTRACT

Achieving competency at electrocardiogram (ECG) interpretation among cardiology subspecialty residents has traditionally focused on interpreting a target number of ECGs during training. However, there is little evidence to support this approach. Further, there are no data documenting the competency of ECG interpretation skills among cardiology residents, who become de facto the gold standard in their practice communities. We tested 29 Cardiology residents from all 3 years in a large training program using a set of 20 ECGs collected from a community cardiology practice over a 1-month period. Residents interpreted half of the ECGs using a standard analytic framework, and half using their own approach. Residents were scored on the number of correct and incorrect diagnoses listed. Overall diagnostic accuracy was 58%. Of 6 potentially life-threatening diagnoses, residents missed 36% (123 of 348) including hyperkalemia (81%), long QT (52%), complete heart block (35%), and ventricular tachycardia (19%). Residents provided additional inappropriate diagnoses on 238 ECGs (41%). Diagnostic accuracy was similar between ECGs interpreted using an analytic framework vs ECGs interpreted without an analytic framework (59% vs 58%; $F_{1,1333} = 0.26$; $P = 0.61$). Cardiology resident proficiency at ECG interpretation is suboptimal. Despite the use of an analytic framework, there remain significant deficiencies in ECG interpretation among Cardiology residents. A more systematic method of addressing these important learning gaps is urgently needed.

RÉSUMÉ

Atteindre la capacité d'interprétation d'un électrocardiogramme (ECG) des résidents en cardiologie met traditionnellement l'accent sur l'interprétation d'un nombre prédéfini d'ECG pendant la formation. Cependant, il y a peu d'arguments pour étayer cette approche. En outre, il n'existe pas de données documentant la compétence d'interprétation des ECG par les résidents en cardiologie, qui deviennent de facto l'étalon-or dans leurs communautés de pratique. Nous avons testé 29 résidents en cardiologie lors de l'une de leurs 3 années de programme de formation à l'aide d'un ensemble de 20 ECG recueillis à partir d'une pratique en cardiologie, ceci sur une période d'un mois. Les résidents ont interprété la moitié des ECG en utilisant un cadre analytique standard, et l'autre moitié en utilisant leur propre approche. Les résidents ont été notés sur le nombre de diagnostics correctement et incorrectement posés. La précision diagnostique globale était de 58 %. Sur les 6 diagnostics potentiellement mortels, les résidents en ont manqué 36 % (123 sur 348), y compris une hyperkaliémie (81 %), un QT long (52 %), un bloc cardiaque complet (35 %), et une tachycardie ventriculaire (19 %). Les résidents ont fourni des diagnostics supplémentaires de façon inappropriée sur 238 ECG (41 %). La précision du diagnostic était similaire entre les ECG interprétés à l'aide d'un cadre analytique vs les ECG interprétés sans ce cadre analytique (59 % vs 58 % ; $F_{1,1333} = 0,26$, p = 0,61). La maîtrise de l'interprétation de l'ECG par les résidents en cardiologie n'est pas optimale. Malgré l'utilisation d'un cadre d'analyse, il reste des lacunes importantes dans l'interprétation d'ECG chez les résidents en cardiologie. Une méthode plus systématique pour combler ces lacunes importantes d'apprentissage est une nécessité urgente.

Establishing competency in electrocardiogram (ECG) interpretation has traditionally relied on residents interpreting a target number of ECGs.[1] However, there is little evidence to

suggest that achieving a minimum number of ECG interpretations could actually guarantee competency in this skill.[2] There is a paucity of literature that details the ECG interpretation skills of cardiology residents. We believe that there is a need to document a resident's competency in this skill because many will graduate to become the principal ECG readers in hospitals and diagnostic laboratories, and will be considered the 'gold standard' of ECG interpretation in their communities.

There is a common belief among educators that the use of an analytic framework involving careful scrutiny of key variables (such as rate, rhythm, axis, etc) reduces interpretation errors among residents, based on the cognitive psychology of errors.[3] Analytic frameworks are lists of key variables to be sequentially considered. For ECGs, a common analytic framework is to examine the rate, rhythm, axis, chamber hypertrophy, signs of ischemia, and intervals in a systematic fashion. Although unlikely to be the only mechanism behind the deficiencies noted in previous studies of resident ECG interpretation, this factor can be easily addressed. We therefore hypothesized that the provision of an analytic framework would be associated with fewer ECG interpretation errors among cardiology residents. The purpose of this study was therefore two-fold: (1) to document the proficiency of ECG interpretation among cardiology residents; and (2) to determine if proficiency can be improved by asking cardiology residents to use an analytic framework while interpreting ECGs.

Methods

Ethics approval was obtained through the University of Toronto Ethics Board. Twenty-nine residents (100% of residents in the training program), representing all 3 training years (9 first-, 9 second-, and 11 third-year residents) volunteered for testing after providing informed consent. Residents were tested at the end of June of the academic year and given 1 hour to interpret the 2 packages of 10 preselected ECGs. Residents were randomized to interpret 1 of the 2 ECG packages using a familiar analytic framework focusing on key variables in ECG interpretation: rate, underlying rhythm, QRS axis, chamber hypertrophy, abnormal intervals, and ischemic changes, and the other ECG package in a manner they usually would use to interpret.

ECG selection

Two expert readers (2 cardiologists with an average of 25 years of practice experience) selected 10 ECGs with unambiguous diagnoses from a set of sequential ECGs collected over a 1-month period from a community cardiologist's everyday practice. Diagnoses selected were either believed important to test (eg, normal) or critical diagnoses which included: hyperkalemia, prolonged QT interval, complete heart block, ST-elevation myocardial infarction, ventricular tachycardia, and ventricular pre-excitation. ECGs with more than 1 diagnosis were also included. The median number of diagnoses per ECG was 2 (range, 1-5).

For each of the 10 ECGs selected, a second ECG with similar diagnoses was selected. For example, an ECG demonstrating an ST-elevation inferior myocardial infarction with third degree block was paired with an ECG demonstrating an anterior ST-elevation infarction with bifascicular block. This resulted in 2 packages of similar ECGs, 1 from each pair. All ECGs were then independently and randomly reinterpreted by both experts, who each listed 27 relevant diagnoses based on the ECGs interpreted. A marking scheme for each ECG was derived by consensus of the experienced observers, including predefined critical ECG diagnoses. Agreement between the expert readers in ECG interpretation and diagnoses was 100%. This manner of collecting and selecting ECGs was designed to produce content that was highly representative of the actual day-to-day clinical practice of a community cardiologist.

Analysis

Diagnostic accuracy was defined as the percentage of diagnoses identified correctly for each ECG. Analytic framework, postgraduate level of training, and number of diagnoses present on each ECG were entered as fixed effects into analysis of variance testing. Post hoc testing was performed with the Bonferroni correction with a predetermined threshold of $\alpha < 0.05$. All analyses were conducted using SPSS version 17 (SPSS, Inc, Chicago, IL).

Results

Overall diagnostic accuracy for all 27 diagnoses was 58%, ranging from 3% for a diagnosis of lead misplacement to 93% for that of supraventricular tachycardia (Table 1). Residents failed to identify 36% of the predefined critical diagnoses (128 of 348). The most frequent critical diagnoses that were missed included: hyperkalemia (81%), long QT (52%), and complete heart block (35%). Forty-eight percent of residents missed 3 or more critical diagnoses. Residents provided additional inappropriate diagnoses on 238 ECGs (41%; Table 2). The most common inappropriate diagnoses provided were conduction abnormalities on ECGs demonstrating pre-excitation or ventricular rhythms (12%). Overdiagnosis of chamber enlargement was noted in 10% of ECGs. In 8% of cases, ventricular hypertrophy was misdiagnosed in the setting of pre-excitation or conduction abnormalities.

Overall diagnostic accuracy of interpretation varied by level of cardiology training ($54.0 \pm 2.6\%$, $63.6 \pm 2.6\%$, and $61.8 \pm 2.8\%$ for first-, second-, and third-year cardiology residents respectively; $F_{2,1333} = 3.82$; $P = 0.02$). Post hoc testing with the Bonferroni correction revealed significantly lower scores among first-year residents (mean difference compared with second- and third-year residents, $10 \pm 3.2\%$; $P = 0.01$ and $-9 \pm 3.3\%$; $P = 0.02$, respectively). No difference was found between the second- and third-year residents (mean difference, $1 \pm 3.3\%$; $P = 1.0$).

Diagnostic accuracy was no different among ECGs interpreted using an analytic framework vs ECGs interpreted without an analytic framework (59% vs 58%; $F_{1,1333} = 0.26$; $P = 0.61$). This did not vary depending according to the specific ECG diagnosis, number of diagnoses present on the ECG, or year of training (Ps all > 0.6). The number of inappropriate additional diagnoses did not differ between ECGs interpreted with and without an analytic framework (40% vs 42%; $\chi^2 = 0.74$).

Discussion

Competency in ECG interpretation is important for medical and legal reasons, and is of utmost importance in maintaining high standards of patient care. To our knowledge, this is the first report of ECG interpretation competency among cardiology residents. The performance of cardiology residents in this study is similar to previous studies. A systematic review found resident accuracy in ECG interpretation varied from 46% to 83% compared with reference standards.[4]