Diagnosis and management of wide complex tachycardia in the emergency department

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Abstract

Introduction While wide complex tachycardia (WCT) is potentially lethal, little is known about its incidence in the ED or about expertise of ED physicians in diagnosing and treating it. We sought to compare WCT ED cases that were primary arrhythmias versus those with rapid heart rate secondary to medical issues, as well as the accuracy of ED diagnosis and appropriateness of treatment.

Methods We conducted a health records review at a large academic hospital ED staffed by 95 physicians and included consecutive patients over 28 months (2018–2020) with WCT (heart rate ≥ 120 bpm and QRS ≥ 120 ms). Cases were adjudicated for the accuracy of ECG diagnosis versus the cardiology read and for correctness of treatment as per guidelines by two ED physicians and one cardiologist.

Results We identified 306 eligible cases (0.2% of all ED visits): mean age 73.9 years, male 66.0%, admitted 53.3%, died in ED 2.3%. Primary arrhythmias and secondary tachycardias were each 50.0% (95% CI 44.4–55.6%). ED physicians correctly interpreted 81.2% of ECGs. The most common presenting arrhythmias and % correct were: atrial fibrillation 42.7% (95.0%), atrial flutter 22.2% (63.5%), sinus tachycardia 12.0% (78.6%), and supraventricular tachycardia (SVT) 11.1% (68.0%). Treatments were judged optimal in 84.3% of primary WCT and 86.9% in secondary WCT. Treatments were suboptimal for: inappropriate drug (3.9% for primary versus 1.3% for secondary), failure to reduce heart rate < 100 prior to discharge home (9.1% for primary versus 34.4% for secondary), and not treating the underlying cause in 5.9% of secondary WCT.

Conclusions WCT cases were evenly split between primary arrhythmias and secondary cases. ED physicians interpreted the ECG correctly in 81% but over-called atrial flutter and SVT. They implemented appropriate care in most cases but sometimes failed to adequately control heart rate or to treat the underlying condition, suggesting opportunities to improve care of WCT in the ED.

Keywords Emergency department · Arrhythmia · Wide QRS complex

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Résumé

Introduction Bien que la tachycardie à complexe large (*wide complex tachycardia* WCT) soit potentiellement mortelle, on sait peu de choses sur son incidence aux urgences ou sur l'expertise des médecins des urgences en matière de diagnostic et de traitement. Nous avons cherché à comparer les cas WCT aux urgences qui étaient des arythmies primaires par rapport à ceux avec une fréquence cardiaque rapide secondaire à des problèmes médicaux, ainsi que la précision du diagnostic des urgences et la pertinence du traitement.

Méthodes Nous avons effectué un examen des dossiers médicaux dans les urgences d'un grand hôpital universitaire où travaillent 95 médecins et avons inclus des patients consécutifs sur 28 mois (2018–2020) présentant un WCT (fréquence cardiaque ≥ 120 bpm et QRS ≥ 120 ms). Les cas ont été jugés par deux médecins des urgences et un cardiologue pour l'exactitude du diagnostic ECG par rapport à la lecture cardiologique et pour l'exactitude du traitement conformément aux directives.

Résultats Nous avons identifié 306 cas éligibles (0,2 % de toutes les visites aux urgences) : âge moyen 73,9 ans, hommes 66,0 %, admis 53,3 %, décédés aux urgences 2,3 %. Les arythmies primaires et les tachycardies secondaires étaient chacune de 50,0 % (IC 95 % 44,4–55,6 %). Les médecins des urgences ont interprété correctement 81,2 % des ECG. Les arythmies les plus fréquentes et les pourcentages d'interprétation correcte étaient les suivants : fibrillation auriculaire 42,7 % (95,0 %), flutter auriculaire 22,2 % (63,5 %), tachycardie sinusale 12,0 % (78,6 %) et tachycardie supraventriculaire (TSV) 11,1 % (68,0 %). Les traitements ont été jugés optimaux dans 84,3 % des WCT primaires et 86,9 % des WCT secondaires. Les traitements étaient sous-optimaux pour les raisons suivantes : médicament inapproprié (3,9 % pour le primaire contre 1,3 % pour le secondaire), incapacité à réduire la fréquence < 100 avant le retour à domicile (9,1 % pour le primaire contre 34,4 % pour le secondaire) et absence de traitement de la cause sous-jacente dans 5,9 % du WCT secondaire.

Conclusions Les cas de WCT étaient répartis uniformément entre les arythmies primaires et les cas secondaires. Les médecins du service d'urgence ont correctement interprété l'ECG dans 81 % des cas, mais ont surévalué le flutter auriculaire et la TSV. Ils ont mis en œuvre des soins appropriés dans la plupart des cas, mais n'ont pas toujours réussi à contrôler adéquatement la fréquence cardiaque ou à traiter la maladie sous-jacente, ce qui laisse entrevoir des possibilités d'améliorer les soins de WCT au service d'urgence.

Clinician's capsule

What is known about the topic?

While wide complex tachycardia (WCT) is potentially lethal, little is known about the expertise of ED physicians in its management.

What did this study ask?

This academic ED health records review evaluated 306 consecutive patients with WCT (heart rate ≥ 120 bpm and QRS ≥ 120 ms).

What did this study find?

There were equal numbers of primary and secondary arrhythmias; physicians interpreted 82% of ECGs correctly and sometimes failed to deliver appropriate care.

Why does this study matter to clinicians?

There are opportunities to improve ED management of WCT including controlling heart rate and treating the underlying medical condition.

to sinus tachycardia with aberrancy, while others are more serious and are due to ventricular tachycardia (VT) or ventricular pre-excitation syndromes. Other cases of WCT are accelerated ventricular response due to electrolyte imbalances, sepsis, drug toxicity, and many other medical conditions [1–3]. Distinguishing between the types of WCT may be difficult yet must be done rapidly to determine the correct treatment [2, 3].

The accurate diagnosis of WCT and identification of its etiology is complicated by the difficulty of rapidly interpreting electrocardiograms (ECGs) in an unwell patient. Several algorithms for WCT ECG interpretation exist; however, despite these tools, there continues to be misidentification of the underlying mechanism based on the initial ECG analysis in the ED [2–6]. Current approaches to management of WCT are outlined in the Advanced Cardiac Life Support (ACLS) guidelines [7]. The ACLS guidelines provide an algorithm for treating WCT, with the first step being the determination of hemodynamic stability; unstable patients presenting with WCT should receive immediate cardioversion. Depending on the etiology of the WCT, several treatment options exist for stable patients [6–9]. To our knowledge, there exists very little literature on the accuracy of WCT diagnosis and the appropriateness of its management in the ED. We hypothesize that there is some inaccuracy in the diagnosis of WCT for patients presenting to the ED with this arrhythmia. Further, we believe there to be considerable variation in the

Introduction

Wide QRS complex tachycardia (WCT), defined as a heart rate greater than 100 beats per minute accompanied by a widened QRS complex (≥ 120 ms), is an uncommon but potentially lethal arrhythmia treated in the emergency department (ED) [1–3]. Some cases are benign and are due

approach to management, due to the complexity of diagnosis and limited evidence base to guide clinical practice.

The overall goal of this study was to better understand the burden of disease presented by WCT and identify opportunities for improved care in the ED. Specifically, we sought to determine the incidence and etiology of WCT requiring management in a large academic hospital ED, as well as the disposition and outcomes of these cases. We wished to evaluate the accuracy of diagnosis of underlying etiology by ED physicians and to examine the variation and appropriateness of management.

Methods

Design and setting

This was a health records review of patients who presented with WCT to one ED of a tertiary care academic hospital over a 28-month period in 2018–2020. The Ottawa Hospital has 1200 beds and is in Ottawa, Ontario, Canada. The two EDs are staffed by 95 certified attending physicians and has 160,000 mostly adult visits per year. The University of Ottawa Department of Emergency Medicine has 55 residents and 20 fellows in research, education, ultrasound, simulation, and prehospital and transport medicine programs. The University of Ottawa Heart Institute is adjacent to the Civic Campus ED and is a major cardiovascular centre.

Participants

We enrolled consecutive visits of patients aged 18 years or older with evidence of a QRS complex ≥ 120 ms on their initial ECG in the ED as well as a heart rate ≥ 120 bpm. These cases were identified by search of the Heart Institute ECG database. We chose a cut-off of 120 bpm to focus on more challenging cases and to exclude the large number of patients with sinus tachycardia and bundle branch block. If multiple ECGs were completed during the same ED visit, only the first ECG showing WCT was used. We were particularly interested in documenting ED management practices over the entire 28-month study period and, therefore, did not exclude subsequent ED visits. The first ED visit during the study period was designated as the index visit. We obtained approval from the Ottawa Health Science Network Research Ethics Board.

Measures and data collection

We followed most aspects of the RECORD statement for studies of routinely collected health data [10]. The sources of data were the ED health record (including triage, nursing, and physician notes), hospital electronic records (clinical,

laboratory, imaging, and death certificate), clinic records, and ECG database. The latter has been maintained by the cardiology department for many years and includes all ECGs performed throughout the institution. It is searchable by multiple parameters. The following information was collected from each patient's medical chart: demographic and medical history data; ED treatments administered; adverse events; final ED diagnosis as a primary arrhythmia or increased heart rate secondary to another medical cause; and disposition and clinical outcomes. The ED physician's interpretation was obtained from the dedicated ECG interpretation line on paper charts prior to the adoption of the electronic medical record (EMR), or from the clearly recorded and time-stamped interpretation on the EMR (Epic Systems Corporation). All potential cases and medical records were reviewed by the first reviewers (J.L., S.A.) and further reviewed by a staff physician (I.G.S. or D.E.). Rather than measuring agreement we sought consensus.

Primary arrhythmia was defined as any atrial, supraventricular, or ventricular rhythm, excluding permanent AF [8]. Secondary WCT was defined as a rapid rate associated with an underlying medical condition or acute reversible precipitant (e.g. infection, acute respiratory or cardiac pathology). The differentiation of a primary arrhythmia versus secondary to a medical cause was based upon review of the clinical picture, cardiology consults, discharge summaries, review of prior ECGs, and discussion amongst two emergency physicians and one cardiac electrophysiologist (M.S.G.). Similar sources and discussions were used to determine the ED physician accuracy of clinical diagnosis and appropriateness of treatment.

Appropriateness of treatment was judged by the senior authors based on their clinical experience and standard guidelines [7, 8, 11]. We classified suboptimal treatment as: inappropriate drug or dose, failure to reduce heart rate below 100 bpm for patients discharged from the ED [12, 13], ACLS guidelines not followed for VT, failure to cardiovert AF/AFL as indicated by Canadian guidelines [14], oral anticoagulants not prescribed when indicated by Canadian guidelines [15], and failure to treat underlying medical cause.

Sample size and data analysis

Based on initial review of the ECG database, we expected to enroll 300 eligible cases from the 28-month period. Analysis employed descriptive statistics appropriate for continuous, ordinal, and categorical outcomes.

Table 1 Baseline characteristics of 306 emergency department patients with rapid heart rate and wide QRS complexes

Characteristics	Primary WCT <i>N</i> = 153	WCT secondary to underlying cause <i>N</i> = 153	Total visits (<i>N</i> = 306)
Age in years, mean	72.5	75.4	73.9
Range	19–102	35–99	19–102
Male, %	68.6	63.4	66.0
Initial vital signs, mean			
Heart rate, bpm, (<i>N</i> = 152:150:302) ^a	135.2	127.5	131.4
Systolic blood pressure (mmHg) (<i>N</i> = 150:148:298)	120.6	128.6	124.6
Temperature ≥ 38.0 °C, % (<i>N</i> = 139:141:280)	0.7	9.2	6.7
Hours from onset, mean (<i>N</i> = 121:98:219)	13.3	18.8	15.7
Time of onset uncertain, %	20.9	36.0	28.4
Main presenting complaint, %			
Palpitations	53.6	5.2	29.4
Shortness of breath	8.5	32.0	20.3
Chest pain	19.6	10.5	15.0
Weakness	4.5	6.5	5.6
Cardiac arrest	1.3	7.2	4.3
Ventricular fibrillation	0.0	2.0	1.0
Pulseless ventricular tachycardia	1.3	2.0	1.6
Pulseless electrical activity	0.7	2.0	1.3
Fever	1.3	3.3	2.3
ICD shock	2.6	0.0	1.3
Other	8.5	34.0	21.2
Acuity, %			
CTAS score < 2 (<i>N</i> = 148:150:298)	7.4	22.7	15.1
GCS score < 15 (<i>N</i> = 142:139:281)	7.8	38.9	23.1
Unstable vital signs, %			
Hypotensive SBP < 90	15.0	15.0	15.0
Pulseless on arrival	0.7	2.0	1.3
Pulseless after arrival	3.3	3.3	3.3
Arrival by ambulance, %	32.7	62.1	49.0
Previous ECG, %	84.3	77.8	81.1
History of arrhythmia, %	68.0	54.3	61.1
Atrial fibrillation/flutter	54.9	51.6	53.3
SVT (SNRT, AVNRT, AVRT)	8.5	1.3	4.9
Ventricular tachycardia/fibrillation	5.9	1.3	3.6
Medical history, %			
Hypertension	60.8	62.8	61.8
Coronary artery disease	32.7	32.7	32.7
Heart failure	30.7	33.3	32.0
Diabetes mellitus	22.2	31.4	26.8
Valvular heart disease	23.5	15.0	19.3
COPD/asthma	13.7	18.3	16.0
Pacemaker/ICD	16.3	15.7	16.0
Stroke/TIA	15.7	15.0	15.4
Cardiac ablation	11.8	2.0	6.9
Current medications, %			
Anti-arrhythmic medication (<i>N</i> = 20:9:29)	13.1	5.9	9.5
Amiodarone	95.0	88.9	93.1
Flecainide	0.0	11.1	3.4
Propafenone	5.0	0.0	3.4

Table 1 (continued)

Characteristics	Primary WCT N=153	WCT secondary to underlying cause N=153	Total visits (N=306)
Rate control medication (N=84:81:165)	54.9	52.9	53.9
Beta-blockers	92.9	88.9	90.9
Calcium channel blocker	7.1	9.9	8.5
Digoxin	3.6	9.9	6.7
Oral anticoagulant	47.1	45.5	45.1
Anti-platelet	32.0	22.9	27.5

Includes both index and subsequent ED visits within study period

WCT wide complex tachycardia, SD standard deviation, ICD implantable cardioverter defibrillator, CTAS Canadian triage and acuity scale, GCS Glasgow coma scale, IQR interquartile range, SBP systolic blood pressure, SVT (SNRT, AVNRT, AVRT) supraventricular tachycardia (sinus nodal re-entrant tachycardia, atrioventricular nodal re-entrant tachycardia, atrioventricular re-entrant tachycardia), COPD chronic obstructive pulmonary disease, TIA transient ischemic attack

^aIndicates correct denominators where data are missing

Results

We identified 372 potential subjects and after excluding 66, enrolled 306 cases into the study (Online Appendix Fig. 1). This equates to an incidence of 11 cases per month or 0.2% of ED visits. The patients had mean age 73.9 years, were male 66.0%, had a mean heart rate 131.4 bpm (maximum 227) (Table 1). The most common presenting complaints were palpitations, shortness of breath, and chest pain; 61.1% had a prior history of arrhythmia. The proportions of primary and secondary WCT were exactly 50.0% (95% CI 44.4–55.6%) each. The secondary cases were more likely to be febrile (9.2% vs 0.7%), to have a Glasgow Coma Scale score < 15 (38.9% vs 7.8%), and to have arrived by ambulance (62.1% vs 32.7%) (Online Appendix Table 1).

The cases with primary WCT were more likely to have an ECG HR $\geq$ 140 (47.7% vs 26.1%) (Table 2). Comparing the primary to secondary WCT cases, the ECG rhythms were: AF (34.0% vs 45.8%), atrial flutter (AFL) (25.5% vs 13.1%), sinus tachycardia (4.6% vs 30.1%), SVT (16.9% vs 4.9%), VT (11.1% vs 0%). Cardiology classified 3.3% of ECGs as uncertain rhythm.

The primary WCT cases were less likely to require resuscitative measures (12.4% vs 24.2%) but were more likely to receive electrical cardioversion/defibrillation (41.2% vs 2.0%) and rhythm or rate control agents (52.3% vs 19.6%) (Table 3). In contrast, the primary WCT cases were much less likely to receive non-cardiac treatments such as IV fluid boluses (18.3% vs 41.8%), antibiotics (3.3% vs 45.8%), analgesics (5.2% vs 32.0%), and diuretics (7.2% vs 22.2%). The secondary WCT cases were much more likely to be admitted (73.2% vs 33.3%) and more likely to go to ICU/CCU/monitored unit (58.2 vs 30.0%) (Table 4). The secondary WCT cases were more likely to die in the ED (3.9% vs 0.7%) and

in the subsequent 14 days (9.8% vs 3.3%). (See also Online Appendix Table 2).

In 20% of cases, the ED physicians failed to record their impression of the ECG rhythm (Table 5). They were most accurate versus the post hoc cardiologist interpretation for AF (95.0%) and VT (88.2%) and less accurate for AFL (63.5%) and SVT (68.0%). Cardiologists classified 7.0% of these ECGs as uncertain rhythm (Online Appendix Table 3).

In Table 6 and Online Appendix Tables 4 and 5, we see that the ED physicians were accurate in their final clinical diagnosis of both primary (88.9%) and secondary (88.2%) cases of WCT compared to that stated in consultation notes or discharge summaries.

We found that the ED physicians provided optimal treatment for 84.3% of primary WCT cases and for 86.9% of secondary cases (Table 7). For the primary cases, the most common treatment issues were failure to lower heart rate to < 100 bpm for patients discharged home (9.1%), inappropriate drug (3.9%), not treating VT according to ACLS guidelines (2.6%), and failure to prescribe oral anticoagulants (2.0%). For the secondary cases, the most common treatment issues were failure to lower heart rate to < 100 bpm prior to discharge home (34.4%), failure to treat the underlying condition (5.9%), and use of inappropriate drug (1.3%).

Discussion

Interpretation

In this first reported review of WCT management in the ED, we found the overall incidence of WCT to be 0.2% of patient visits. These WCT cases in the ED were evenly split between primary arrhythmias and tachycardia secondary to medical issues. The secondary cases were more likely to be

Table 2 Investigations for 306 emergency department patients with rapid heart rate and wide QRS complexes

Characteristics	Primary WCT N=153	WCT secondary to underlying cause N=153	Total visits N=306
Initial ECG Assessment			
Heart Rate, bpm, mean	145.3	134.2	139.8
Heart rate ≥ 140 , %	47.7	26.1	36.9
Heart rate ≥ 150 , %	29.4	10.5	19.9
Rhythm, % ^a			
Atrial fibrillation	34.0	45.8	39.9
Atrial flutter	25.5	13.1	19.3
Sinus tachycardia	4.6 ^b	30.1	17.3
SVT (SNRT, AVNRT, AVRT)	16.9	4.9	10.8
Pre-excited tachycardias	1.3	0.0	0.7
Ventricular tachycardia	11.1	0.0	5.6
Ventricular paced rhythm	2.6 ^c	3.9	3.3
Uncertain interpretation	3.9	2.6	3.3
Interval time, ms, mean			
PR	137.2	136.5	136.7
QRS	142.9	138.2	140.6
QTc	504.4	500.9	502.6
Bundle branch block, %	83.6	90.9	87.3
Laboratory values, %			
1st Troponin > 99th percentile ^d (N=121:139:260)	45.8	50.3	48.0
2nd Troponin > 99th percentile ^d (N=44:41:85)	25.5	17.0	21.2
Chest X-ray, %	41.2	77.1	59.2
Pleural effusion	8.5	27.5	17.9
Heart failure ^e	4.6	20.0	11.7
Infiltrate/consolidation/mass	1.3	17.0	9.2
Cardiomegaly	5.8	11.1	8.5

Includes both index and subsequent ED visits within study period

WCT wide complex tachycardia, SD standard deviation, SVT (SNRT, AVNRT, AVRT) supraventricular tachycardia (sinus nodal re-entrant tachycardia, atrioventricular nodal re-entrant tachycardia, atrioventricular re-entrant tachycardia)

^aECG rhythm as determined by the final cardiologist interpretation

^bSinus tachycardia included as primary as the cardiac rhythm changed during the course of treatment in the emergency department, requiring treatment as a primary WCT

^cVentricular paced rhythm included as primary as the cardiac rhythm changed during the course of treatment in the emergency department, requiring treatment as a primary WCT

^dIncludes both Troponin T and Troponin I assays as the laboratory test was changed from Troponin I to Troponin T during the study period

^eIncludes indications of pulmonary edema, perihilar edema, Kerley B lines, and vascular redistribution

febrile, have a GCS score < 15, have arrived by ambulance, have an ECG HR < 140, receive IV fluid boluses and antibiotics, be admitted, and die within 14 days. 3% of ECG rhythms were interpreted as uncertain diagnosis by cardiologists. The ED physicians interpreted the ECG correctly versus the cardiologist read in 82% of cases but had difficulty always identifying AFL and SVT. Further, the ED physicians were highly accurate in their final clinical diagnosis of both primary and secondary cases. These physicians

provided optimal treatment for the majority of cases, but we did identify opportunities for improvement as discussed below. Differentiating between a primary arrhythmia and secondary tachycardia is essential as the treatments and outcomes are quite different.

Table 3 Treatment in ED of 306 emergency department patients with rapid heart rate and wide QRS complexes

Treatment details (%)	Primary WCT N= 153	WCT secondary to underlying cause N= 153	Total visits N= 306
Resuscitation, %	12.4	24.2	18.3
IV fluid bolus > 250 ml	11.1	20.9	16.0
Vasopressors	3.9	11.8	7.8
Intubation	2.6	11.8	8.8
Bag valve mask	3.3	9.2	6.2
Cardiopulmonary resuscitation	3.3	4.6	3.9
Duration of CPR, min, mean	0.7	2.0	1.3
Electrical cardioversion/defibrillation, % (N=63:3:66)	41.2	2.0 ^a	21.6
Shocks delivered, median	1	1	1
Sedation	39.2	0.0	19.6
Synchronized	39.9	0.7	20.3
ROSC achieved	2.6	2.0	2.3
Did spontaneous breathing resume	1.3	0.7	1.0
If ROSC were vasopressors required	2.0	2.0	2.0
Subsequent rhythm, %			
Normal sinus rhythm	37.9	0.7	19.3
Brady arrhythmia	0.0	0.7	0.3
Asystole	0.7	0.0	0.3
Other	0.7	0.7	0.7
No change	2.0	0.0	1.0
Adverse airway events, %	14.4	0.0	13.7
Other non-pharmacological rhythm control, % (N= 15:0:15)	9.8	0.0	4.9
Vagal manoeuvre	9.2	0.0	4.6
Magnet	0.7	0.0	0.3
Rhythm or rate control medication given, % (N= 80:30:110)	52.3	19.6	36.0
Beta blocker ^b	28.1	17.0	22.5
Amiodarone ^b	19.0	3.3	11.1
Calcium channel blocker ^b	11.1	2.0	6.5
Adenosine	12.4	0.0	6.2
Procainamide/lidocaine	8.5	0.7	4.6
Magnesium	6.5	1.3	3.9
Other	0.0	1.3	0.7
Adverse reactions to rhythm or rate control medication, %	3.9	3.3	3.6
Non-cardiac treatments, %	39.2	89.5	64.4
IV fluid bolus > 250 ml	46.7	41.8	30.1
Antibiotics	8.3	45.8	24.5
Analgesics	13.3	32.0	18.6
Diuretics	18.3	22.2	14.7
Spontaneous conversion to NSR %	16.3	8.5	12.4

WCT wide complex tachycardia, IV Intravenous, SD standard deviation, IQR interquartile range, ROSC return of spontaneous circulation, NSR normal sinus rhythm

Includes both index and subsequent ED visits within study period

^aThree cases where defibrillation was required, due to cardiac arrest, during the treatment of a patient with WCT secondary to underlying cause

^bIncludes IV and PO doses

Previous studies

While we identified guidelines and review articles

discussing management of WCT, we found no studies of WCT prevalence or management in the ED. There are many articles addressing the deficiencies of ECG interpretation

Table 4 Disposition and follow-up (%)

Disposition details	Primary WCT <i>N</i> = 153	WCT secondary to underlying cause <i>N</i> = 153	Total <i>N</i> = 306
Patient discharged by the ED physician, %	58.1	18.3	38.2
Disposition, %			
Discharged home	64.7	20.9	42.8
Admitted	33.3	73.2	53.3
Monitored area	16.3	34.0	25.2
CCU/ICU	13.7	24.2	19.0
Ward	3.3	15.0	9.2
Death in ED	0.7	3.9	2.3
Transfer	1.3	2.0	1.6
Admitting service, % (<i>N</i> = 51:112:163)			
Cardiology	80.4	27.7	44.2
Medicine	15.7	50.9	39.9
Critical care	3.9	16.1	12.3
Time to consultant at bedside, hours, median, (<i>N</i> = 65:123:188)	4.2	4.3	4.3
ED length of stay, hours, median	5.8	11.1	7.8
Outpatient follow-up recommended, % (<i>N</i> = 93:27:120)	60.8	17.7	39.2
Cardiology	80.6	44.4	72.5
Family medicine	24.7	48.1	30.0
Other	5.4	18.5	8.3
Death in ED, % (<i>N</i> = 1:6:7)	0.7	3.9	2.3
Cardiac	100.0	33.3	42.9
Other	0	66.6	57.0
Return ED visit within 2 weeks, %	15.7	10.5	13.1
Death within 14 days, % (<i>N</i> = 5:15:20)	3.3	9.8	6.5
Cardiac	60.0	40.0	45.0
Other	40.0	60.0	55.0

WCT wide complex tachycardia, ED emergency department, CCU/ICU coronary care unit/intensive care unit, IQR interquartile range

Includes both index and subsequent ED visits within study period

Table 5 Accuracy of ECG rhythm identification for 234 emergency department patients with rapid heart rate and wide QRS complexes where ED physician recorded their interpretation

	Cardiologist interpretation (<i>N</i> = 234) (%)	ED physician % agreement
Atrial fibrillation	100 (42.7)	95.0
Atrial flutter	52 (22.2)	63.5
Sinus tachycardia	28 (12.0)	78.6
SVT (SNRT, AVNRT, AVRT)	25 (11.1)	68.0
Pre-excited tachycardia	2 (0.9)	0
Ventricular tachycardia	17 (7.3)	88.2
Ventricular paced rhythm	10 (4.3)	80.0
Total	234 (100.0)	81.2

ECG electrocardiogram, ED emergency department, SVT (SNRT, AVNRT, AVRT) supraventricular tachycardia (sinus nodal re-entrant tachycardia, atrioventricular nodal re-entrant tachycardia, atrioventricular re-entrant tachycardia)

by physicians in general, but none dealing with WCT [16]. Many articles focus on identifying acute myocardial infarction or the accuracy of machine interpretations.

Limitations

As this was a health records review, some information was occasionally missing or incomplete in the clinical record. For example, ED physicians failed to indicate their ECG interpretation in about 20% of cases. Overall, however, there were few missing data. This study was conducted at only one ED site over a limited period of time. Regardless, the ED was staffed by 95 well trained attending physicians and is likely representative of most academic EDs in the U.S. and Canada. While we only reviewed 28 months of cases, the sample size of 306 cases far exceeds anything previously reported. Our decision to only study patients with heart rate ≥ 120 bpm was arbitrary but gave us a higher yield of

Table 6 Accuracy of determination of clinical diagnosis for 306 emergency department patients with rapid heart rate and wide QRS complexes

Final diagnosis	Final diagnosis according to consultant or discharge summary (%) (<i>N</i> = 306)	ED physician % agreement with final diagnosis
Primary arrhythmia	153 (100.0)	98.1 ^a
Acute atrial fibrillation	69 (45.1)	91.3
Acute atrial flutter	34 (22.2)	88.2
SVT (SNRT, AVNRT, AVRT)	20 (13.1)	80.0
Pre-excited atrial fibrillation	2 (1.3)	50.0
Ventricular tachycardia	27 (17.6)	96.3
Uncertain primary arrhythmia	1 (0.7)	0.0
Correctly identified arrhythmia for primary WCT	153 (100.0)	88.9
Secondary to an underlying cause	153 (100.0)	96.1 ^a
Infection	49 (32.0)	93.9
Heart failure/cardiomyopathy	35 (22.9)	80.0
Acute coronary syndrome	14 (9.2)	78.6
Cardiac arrest	10 (6.5)	100.0
Painful condition	9 (5.9)	77.8
Anxiety/dementia/substance use issue	7 (4.6)	100.0
Cerebrovascular/thromboembolism	6 (3.9)	100.0
Respiratory condition ^b	5 (3.3)	80.0
Bleeding/hypovolemia	5 (3.3)	100.0
Acute kidney injury/metabolic disorder/electrolyte abnormality	5 (3.3)	100.0
Other ^c	8 (5.2)	75.0
Correctly identified diagnosis for WCT secondary to underlying cause	153 (100.0)	88.2

SVT (SNRT, AVNRT, AVRT), supraventricular tachycardia (sinus nodal re-entrant tachycardia, atrioventricular nodal re-entrant tachycardia, atrioventricular re-entrant tachycardia;

^aPercentage correctly identify as primary or secondary cases

^bLung infection, COPD, asthma

^cOther secondary causes include medication non-compliance, seizure, autonomic dysreflexia, stimulants, pericarditis, and pancreatitis

seriously ill patients. Our appropriateness of treatment evaluations may also appear to have been arbitrary but are based on current guidelines and significant clinical experience of the emergency medicine and cardiology investigators.

Implications

While ED physicians performed very well, they should consider *opportunities for improvement*. The physicians overcalled AFL on ECG with 1/3 of cases actually being AF, SVT, or sinus tachycardia. Similarly, they overcalled SVT with 40% of cases being AF, AFL, or uncertain. Training and continuing professional development may highlight these challenges. We identified opportunities for improved management in 15% of cases, with the most common omission being failure to adequately reduce the heart rate for both the primary and secondary patients discharged home from the ED. The next most common omission for the secondary cases was failure to treat the underlying cause. Physicians should be mindful of other potential issues such as inappropriate choice of drug, failure to cardiovert or

prescribe anticoagulation for acute AF, according to current guidelines.

ED physicians are highly trained experts in dealing with unstable patients requiring immediate resuscitation [7]. Residents and staff physicians alike should be aware of current guidelines for dealing with stable WCT patients [8, 11]. While there are multiple approaches to identifying VT from sinus tachycardia with aberrant conduction, the most prudent course is to assume VT until proven otherwise. When the *diagnosis is uncertain in unstable patients*, proceed to immediate electrical cardioversion. In *stable patients with uncertain diagnosis*, then guidelines suggest a trial of vagal manoeuvres, adenosine, and IV procainamide. IV amiodarone may be considered but verapamil is not recommended when the diagnosis is uncertain in WCT. Finally, if the prior measures are unsuccessful, then electrical cardioversion is indicated.

Another consideration is that a subsequent *cardiac electrophysiology consultation* may be assisted if ED physicians more often used adenosine to unmask certain arrhythmias that may be difficult to induce in the laboratory but could

Table 7 Appropriateness of treatment of 306 emergency department patients with rapid heart rate and wide QRS complexes

Treatments (%)	Primary WCT N= 153	WCT secondary to underlying cause N= 153	Total N= 306
Optimal treatment (%)	129 (84.3)	133 (86.9)	262 (85.6)
Suboptimal treatment (%) ^a	24 (15.6)	20 (13.1)	44 (14.4)
Failure to lower HR to < 100 bpm if discharged home (N=99:32:131)	9 (9.1)	11 (34.4)	20 (15.2)
Inappropriate drug	6 (3.9) ^b	2 (1.3) ^c	9 (2.9)
Failure to treat underlying cause	NA	9 (5.9)	9 (2.9)
ACLS guidelines not followed for VT	4 (2.6) ^d	0	4 (1.3)
Failure to cardiovert AF/AFL ^e	4 (2.6)	0	4 (1.3)
Oral anticoagulants not prescribed	3 (2.0)	0	3 (1.0)
Inappropriate cardioversion attempt	1 (0.7)	1 (0.7)	2 (0.7)
Inappropriate dose	0	0	0

WCT wide complex tachycardia, bpm beats per minute, HR heart rate, ED emergency department, VT ventricular tachycardia, AF/AFL atrial fibrillation/atrial flutter

^aSome cases have more than one suboptimal treatment concern

^bCases include: one inappropriate use of metoprolol as first-line treatment for ventricular tachycardia, one attempted but unsuccessful cardioversion with amiodarone for a patient with primary atrial fibrillation and a high risk of thrombosis, one use of an AV nodal blocking medication in a patient having ventricular pre-excitation (Wolff–Parkinson–White syndrome), one case where a beta blocker was administered to a patient who presented in heart failure resulting in exacerbation of heart failure, two cases where amiodarone was selected as a medication for cardioversion of atrial fibrillation

^cCases include one attempted but unsuccessful cardioversion with procainamide for a patient with elevated risk of thrombosis and atrial fibrillation secondary to sepsis, one attempt to treat atrial fibrillation secondary to sepsis as a primary arrhythmia using metoprolol

^dFour cases where neither cardioversion nor antiarrhythmic medications were initiated for a patient with ventricular tachycardia

^eCardioversion indicated for AF/AFL according to the 2018 CAEP AF Best Practices Checklist

be amenable to curative catheter ablation therapy. This is particularly the case for atrial flutter and some non-ischemic ventricular tachycardias. Marill and colleagues from Harvard examined 197 patients treated in the ED for regular wide complex tachycardia and found adenosine to be useful and safe as a diagnostic and therapeutic agent [17].

Future studies might evaluate the impact of interventions to improve ECG recognition and management in WCT.

Conclusions

We found that WCT cases in the ED were evenly split between primary arrhythmias and tachycardia secondary to medical issues. The secondary cases were more likely to require admission and to die. ED physicians interpreted the ECG correctly versus the cardiology read in 80% of cases but often overcalled AFL and SVT. The ED physicians, however, were highly accurate in their final clinical diagnosis of both primary and secondary cases. These physicians provided optimal management for the majority of cases, but there were some omissions in care. These findings suggest ED physicians are excellent at managing WCT but that there

are opportunities to improve ECG interpretation and treatment of WCT.

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Declarations

Conflict of interest None.

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