Introduction

Telemetry is an automated communication process by which measurements and other data are collected at remote or inaccessible points and transmitted to receiving equipment for monitoring. Cardiac telemetry was developed in the mid 1960's to monitor patients in hospitals for life-threatening arrhythmias in medical wards outside of the Coronary Care Unit (CCU).^{1, 2} Despite the benefits, which include a reduction in the need for CCU beds, inappropriate use of telemetry may have additional resource implications. This includes emergency department (ED) congestion due to delays with in-patient transfer.

Where possible it is imperative that patients are allocated resources appropriately using standardised evidence based guidelines. Widespread inpatient telemetry use has not demonstrated clear benefits in clinical outcomes. In patients at low risk of arrhythmia and those with atypical chest pain, the addition of telemetry does not improve patient outcomes.³⁻⁷ The main role of telemetry is in patients with high clinical risk or suspicion of arrhythmia in whom management will change as a result of detection.

Perhaps due to insufficient awareness, many Australian tertiary hospital general medical units are not promoting existing guidelines to assist with appropriate inpatient cardiac monitoring. Most patients are admitted through the emergency department and the

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decisions regarding telemetry are decided by the treating emergency physician or the admitting medical registrar, with variable adherence to international recommendations.⁸

In 1991, the American College of Cardiology (ACC) published guidelines for in hospital cardiac monitoring of adults for the detection of arrhythmias.⁹ These guidelines were subsequently revised in conjunction with the American Heart Association (AHA) in 2004.⁸

One key revision included separating cardiac diagnoses and conditions into three classes, each with a different priority for cardiac monitoring (see table 1). Cardiac monitoring is indicated for all patients with conditions and diagnoses in Class I, which includes patients with a high risk of developing serious arrhythmias. For conditions and diagnoses in Class II, cardiac monitoring is indicated in only some patients with an intermediate risk of developing serious arrhythmias. Finally, the guidelines suggested that cardiac monitoring for Class III conditions and diagnoses are not required because of the low risks of serious arrhythmias.⁸ We hypothesized that the use of these established guidelines to assist in clinical decision making would reduce inappropriate telemetry use and improve patient flow.

Methods

The initial audit (phase 1) consisted of a prospective observational study assessing telemetry use at a major metropolitan hospital over a six-month period from March to August 2011.

Patients monitored in both CCU (using remote telemetry units) and the ward were included

to assess the rates of overall telemetry use within the hospital. Baseline patient demographics, cardiac risk factors as well as telemetry data and inpatient clinical outcomes were sought from medical records. Using the admission data patients were categorised according to the American Heart Association guidelines: where telemetry was indicated (Class I), may be indicated (Class II) and not indicated (Class III).

Between February to May 2015 a prospective phase II (baseline) study was conducted to confirm if the results from phase I could be replicated given the elapsed time between the two data collection periods. This was followed by a phase II prospective interventional study (May to August 2015) involving the implementation of the AHA telemetry guidelines and a standardized telemetry ward round conducted by the senior medical registrar. Education regarding indications for telemetry was provided to all admitting medical registrars during the study period and a new telemetry request form was developed. Ethics approval was obtained from the institution's Human Research Ethics Committee.

Inclusion criteria for patients in the interventional study included adult patients > 18 years admitted under the general medicine unit with initiation of telemetry within 24 hours of admission. Exclusion criteria included patients requiring intensive or coronary care admission (where remote telemetry was not performed), patients requiring telemetry admitted under specialty medicine or surgical units as well as patients discharged from the ICU to telemetry beds.

All patients recruited in phase II (intervention) were admitted to a telemetry bed following the completion of a standardized telemetry request form. Telemetry data was reviewed daily by a senior registrar and significant events conveyed to treating teams. Significant events on telemetry were defined as sinus bradycardia < 35 beats per minute (for longer than 30 sec), new onset atrial flutter/fibrillation (AF), pauses > 3 sec, high grade atrioventricular block, ventricular arrhythmias (ventricular tachycardia/ventricular fibrillation or frequent ventricular ectopy) and other supraventricular arrhythmias. In patients with a known history of AF a significant event was defined as a persistent heart rate > 150 beats per minute. Data was collected on cardiac event rates, rates of permanent pacemaker (PPM) insertion and changes to cardiac medications. Decisions regarding early discharge from remote telemetry were made in conjunction with the treating team, and communicated to the nurse unit manager. The primary endpoints included the percentage reduction of patients with class III indications (telemetry not-indicated) admitted to a telemetry bed as well as reduction in length of stay/duration of telemetry.

All categorical variables were presented as percentages and continuous variables presented as means/standard deviation (if normally distributed) or median/IQR (if not normally distributed). Statistical significance was performed using the Chi-Squared test for categorical data, Student's t-test/One-way ANOVA for normally distributed continuous data and the Mann-Whitney U test was utilized for non-parametric data. Analyses were considered to be

statistically significant if two tailed p values were < 0.05 . Statistical analysis was performed using SPSS v.22 (SPSS, Chicago, Illinois).

Results

Phase one: Prospective observational study

Over the six-month study period, 200 patients were placed on telemetry. Patient variables are described in table 3. The cohort demonstrated significant rates of hypertension (66%), dyslipidemia (46%), diabetes (30%), congestive cardiac failure (20%) and ischaemic heart disease (30%). 40% of the cohort were male with a median age of 82 years.

There were nine (4%) patients with a class I indication, 116 (58%) with a class II indication and 75 (38%) with a class III indication for telemetry (see table 2 and figure 1). Of class I patients, two (22%) had an arrhythmia that warranted implantation of a permanent pacemaker. The first patient presented with syncope with an initial electrocardiogram (ECG) demonstrating Mobitz type II block. The other presented with acute pulmonary oedema in the setting of complete heart block (CHB) on the initial ECG. Of the class II patients six (5%) had an arrhythmia detected resulting in an implantation of a permanent pacemaker. Of these six patients, five presented with syncope. Their telemetry results demonstrated high grade atrioventricular nodal block including one with CHB and three with Mobitz type II block. Three of these four patients had the same pathology noted on admission ECG. One

patient had a prolonged sinus pause of 11 seconds (which was not noted on admission ECG). One patient presented with dizziness and their baseline ECG and telemetry showed AF with a slow ventricular rate below 35 beats per minute. In class III patients none had arrhythmias that required pacemaker implantation or a change in medical management.

Phase two: Prospective interventional study

Phase two: Baseline characteristics and comparison to phase one

During the three-month phase II (baseline) period 74 patients meeting the inclusion criteria were placed on telemetry. 65 patients were placed on telemetry during the three-month phase II (intervention) period. There were fewer male patients in the phase II (intervention) group (35%) than the phase II (baseline) group (57%) ($p=0.01$). There were no other significant differences between baseline characteristics in the two studied groups (Table 3). Admission diagnoses leading to telemetry were similar in both groups and are summarized in Table 4.

A summary of the results is shown in figure 2. There were more patients with class I indication for telemetry noted in phase II (baseline) compared to phase I ($p = 0.01$). The number of patients with class II and III were similar in phase I and phase II (baseline).

Phase two: Telemetry indications

Data showing the various class indications at baseline and intervention is shown in Table 4.

Following implementation of the new telemetry request form and telemetry round the percentage of patients with an AHA Class III indication (telemetry not indicated) decreased from 38% to 11% ($p < 0.001$). Compared to phase II (baseline), phase II (intervention) had no significant difference in patients with class I indications (18% vs 14%, $p = 0.43$) however, there was a significant increase in proportion of Class II patients (71% vs 49%, $p = 0.008$).

Phase two: Clinical outcomes

A summary of the clinical outcomes is shown in Table 5. There were two deaths during phase II (intervention) - both from non-cardiac causes in patients who had previously been discharged from monitored beds compared with no deaths at phase II (baseline) ($p=0.13$). One patient died from gastrointestinal bleeding and hepatic encephalopathy related to liver cirrhosis, whilst the other patient died from hospital acquired pneumonia. Phase II (intervention) was associated with a reduction in telemetry duration (1.8 vs 2.4 days, $p = 0.047$) and an increase in cardiac medication changes (46% vs. 28%, $p = 0.03$). There was no significant difference between both groups in overall length of stay, PPM insertion or the number of events captured ($p>0.05$). There were no cardiac arrests requiring cardio-pulmonary resuscitation (CPR) during the follow up period.

During phase II (intervention) 6/12 patients (50%) with class I indication had a significant event noted on telemetry compared with 24/46 (52%) with class II indication. Of the seven patients with class III indication, none had a significant event noted on telemetry. A total of three patients had PPM insertion in phase II (intervention). One patient was in class I and presented with completed heart block whilst two other patients were in class II and presented with unexplained syncope felt to be secondary to paroxysmal bradyarrhythmias. They were subsequently noted to have sinus bradycardia and AF with slow ventricular rate respectively. No patients in class III had PPM insertion.

Discussion

Our study found that, at baseline, more than one third of patients on telemetry did not meet guideline-directed criteria for cardiac monitoring. Our rate of appropriate telemetry use (approx. 70%) is similar to other reported studies.¹⁰⁻¹³ Following the intervention there was a significant reduction in inappropriate telemetry use (from 38% to 11%). We have implemented an intervention to reduce inappropriate telemetry use in tertiary general medicine units. This comprised of dissemination and education of existing guidelines, a telemetry admission form and a daily telemetry ward round. Our intervention addresses several current deficiencies including use of limited resources, patient flow through the emergency department and education to junior medical staff.

The telemetry admission form based on the ACC guidelines⁸ can be used by both emergency department staff and admitting medical registrars. The guidelines help assist junior doctors in clinical decision making and help to make clinicians aware that some patients may be safely managed in non-telemetry beds. There have been several published studies which have shown that the use of telemetry in those at low risk (ie. Class III indication), did not change any significant clinical outcomes.^{3, 5-8, 14, 15} Hence by avoiding telemetry in these patients we do not compromise patient care, but instead allocate our resources to patients who will benefit the most from them. To make the guidelines easier to use in clinical practice, we can adopt a “indicated” and “not-indicated” format. Using this format 89% of telemetry admissions in our study were indicated following the implementation of a guideline-based admission form.

The value of cardiac monitoring is overestimated by many physicians.¹⁵ There is a common belief that patients on telemetry are likely to benefit from monitoring given the possibility of dysrhythmia detection as well as closer nursing observation. Where telemetry may be useful is the detection of arrhythmias which may warrant intervention such as pacemaker insertion. There is evidence to suggest that patients at low risk do not benefit from monitoring. In patients at low risk of acute coronary syndrome, Snider *et al.*⁷ and Saleem *et al.*⁵ both did not show any additional benefit with monitoring. There was no overall reduction in mortality and overall arrhythmia rates were very low in this cohort. Mohammad *et al.*¹⁶ found no improvement in survival in patients who were monitored at

the time of in-hospital cardiac arrest compared to non-monitored patients. In our study, there were no cardiac arrests and overall no significant rise in event rate post intervention. Our definition of significant events included all major tachy/bradyarrhythmias including frequent ventricular ectopy hence our event rates are higher than those reported elsewhere.^{2, 3, 5-7, 15-17} Larson *et. al.*² suggested that an increase in low risk (class III) patients on telemetry has the potential to desensitize staff to telemetry alarms thereby increasing the risk of missing potentially serious events.

There was no significant change in class I, however, a rise in the number of class II indications was observed. The reason for this increase is unclear however the intervention period coincided with winter, during which there was an expected increase in admissions and clinically unwell patients. There were more patients admitted with electrolyte imbalance in phase II (intervention) which contributed to the difference noted between both groups. There were also a higher proportion of female patients in phase II (intervention). It is unclear if any of these reasons contributed to the difference seen between both groups.

Educating registrars about telemetry and having a guideline based admission form improves telemetry assessment. There is improved awareness of the potential benefits gained from telemetry and better patient selection. This may also be associated with an improvement in

medication review and a better understanding of the medical issues for each patient. This process may contribute to fewer inappropriate telemetry admissions.

We also noted a significant increase in changes to cardiac medications post intervention (46% vs 28%, $p = 0.03$) despite no significant increase in events captured (46% vs 39%, $p = 0.32$).

The exact cause for this is unclear. It is unlikely that the intervention is associated with a direct change in this outcome measure. This may relate to the presence of other factors such as a higher proportion of acutely unwell patients during the winter period.

The second step in the intervention was the creation of a daily telemetry round conducted by a senior registrar. Medical ward rounds are hindered due to time constraints and interruptions. Clinically unwell patients as well as new patients admitted from the emergency department are often reviewed first. Hence there is often a delay in which monitored patients are seen. This creates several issues; important telemetry events may be missed by treating teams unless highlighted by nursing staff. Secondly, discontinuation of monitoring does not occur in a timely fashion affecting patient flow from the emergency department.^{18, 19} Review of telemetry data by a senior registrar at the start of the day allows for early detection of significant events and allows for expedited discharges from monitored beds. In our study, this led to an overall reduction in the median duration of telemetry by more than 12 hrs (1.8 vs 2.4 days, $p = 0.047$).

The reduction in telemetry duration is felt to be even more significant given the potential for bias following implementation of telemetry guidelines. Patient with class III indications typically have short hospital (and hence telemetry) admissions and are admitted with common issues such as chest pain for investigation, falls for investigation and pre-syncope. Following implementation of telemetry guidelines there is a significant reduction in class III and a rise in class II indications. Those with a more genuine need for cardiac monitoring will likely have a case for a longer monitoring duration. Hence we feel that the observed reduction in telemetry duration suggests that the implementation of a regular telemetry round (as well as guideline based admissions) is useful for most medical units with benefits seen in patient safety, patient flow and overall financial costs.

Telemetry beds are more expensive for the health-care system than standard unmonitored ward beds. If ward based telemetry beds are full, patients may be allocated to more expensive CCU beds, leading to more than a \$1000 per night increase in costs. Inappropriate telemetry reduces patient flow through the ED thus increasing costs if key performance indicators (KPI) are not met. We expect that the improvements to patient flow and reduction in inappropriate telemetry use will address all of the issues raised above and may be associated with significant cost saving to both the hospital and the health care system, as described previously.^{4, 20}

Limitations of this study:

Our limitations include data collection from a single centre with a small sample size. The classification of patients into one of the three AHA classes was sorted by the primary authors (S.R and E.T) potentially leading to classification and interpreter bias. Follow up data post discharge was not collected hence readmission and adverse event rates are unknown. Cost analysis was difficult to perform given multiple variables involved and the potential for overestimation.

Conclusion

Implementation of guideline-based admissions to telemetry and regular telemetry rounds are associated with a reduction in inappropriate telemetry use and a reduction in the duration of telemetry.

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Figure Legends:

Figure 1: Phase 1 - Distribution of telemetry indications by AHA class

Figure 2: Comparison of telemetry indications between Phase I and Phase II (baseline)

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Table 1: ACC/AHA Indications for telemetry (based on Drew et. al.⁸)

Class I	Class II	Class III
<ul style="list-style-type: none"> • Proven/suspected myocardial infarction • Unstable angina • Any life threatening arrhythmia • Myocarditis • Tach arrhythmias requiring type I/III anti-arrhythmic drugs • High grade AV block • Post cardiac surgery • Medication toxicity associated with high risk of arrhythmias 	<ul style="list-style-type: none"> • Syncope felt to be cardiac in nature • Non-life threatening arrhythmias such as atrial fibrillation • Pericarditis • More than 3 days following myocardial infarction • Severe electrolyte abnormality 	<ul style="list-style-type: none"> • Syncope not felt to be cardiac in nature • Chest pain for investigation with low risk for acute coronary syndrome • Post-operative patients at low risk • Chronic stable atrial fibrillation • Ventricular ectopy • Uncomplicated pulmonary embolus

Table 2: Indications for telemetry - Phase 1

Telemetry Indication	Percentage (n) n = 200
Syncope	39 (78)
Chest Pain for Investigation	17 (34)
Atrial Fibrillation	15 (29)
Bradycardia	3 (5)
Tachycardia other than AF	10 (21)
Congestive Cardiac Failure	5 (11)
Other	11 (22)

Table 3: Baseline patient characteristics

Characteristic	Phase I n = 200	Phase II (baseline) n = 74	Phase II (intervention) n = 65	P value
Age - years (SD)	83.3 (14.5)	73.1 (14.9)	71.0 (18.4)	<0.001
Male (%)	87/200 (44)	42/74 (57)	23/65 (35)	0.03
Hypertension (%)	132/200 (66)	45/74 (61)	40/65 (62)	0.66
Atrial Fibrillation (%)	49/200 (25)	21/74 (28)	20/64 (31)	0.53
Ischaemic Heart disease (%)	64/200 (32)	22/74 (30)	16/65 (25)	0.53
Diabetes Mellitus (%)	60/200 (30)	23/74 (31)	14/65 (22)	0.37
Hypercholesterolemia	91/200 (46)	34/74 (46)	22/65 (34)	0.23
Previous PPM/ICD (%)	1/200 (1)	2/74 (3)	5/65 (8)	0.003
Sinus Rhythm on baseline ECG	136/200 (68)	53/74 (72)	39/65 (60)	0.33
Not for Resuscitation at admission	2/200 (1)	18/74 (24)	13/65 (20)	<0.001

Table 4: Comparison of telemetry indications in Phase II (baseline and intervention)

	Baseline	Intervention	p Value
	% (n)	% (n)	
Class I	14 (10)	18 (12)	0.43
Acute Coronary Syndrome	70 (7)	83 (10)	
High Grade AV Block	0 (0)	8 (1)	
Medication error causing prolonged QT	20 (2)	0 (0)	
Ventricular arrhythmias	10 (1)	8 (1)	
Class II	49 (36)	71 (46)	0.008
Unexplained Syncope felt to be due to cardiac cause	53 (19)	41 (19)	
Atrial Fibrillation	25 (9)	26 (12)	
Bradycardia (other than AV block)	11 (4)	11 (5)	
Tachycardia (other than AF)	3 (1)	0 (0)	
Electrolyte Imbalance	0 (0)	9 (4)	
Congestive Cardiac Failure	3 (1)	2 (1)	
Pulmonary Embolus with right heart strain	0 (0)	7 (3)	
Other	6 (2)	4 (2)	
Class III	38 (28)	11 (7)	<0.001
Syncope with normal ECG (unlikely cardiac cause)	64 (18)	57 (4)	
Chest Pain for Investigation	0 (0)	14 (1)	
Atrial Fibrillation	7 (2)	0 (0)	
Congestive Cardiac Failure	7 (2)	0 (0)	
Electrolyte Imbalance	7 (2)	0 (0)	
PE with stable haemodynamics	0 (0)	14 (1)	
Other	14 (4)	14 (1)	

Table 5: Clinical outcomes pre and post-intervention

Outcome	Phase II (baseline) n = 74	Phase II (intervention) n = 65	P value
Median duration on telemetry in days (IQR, SD)	2.4 (2.5, 2.8)	1.8 (1.8, 2.3)	0.047
Patients with events captured on telemetry (%)	28/74 (39)	30/65 (46)	0.32
Median Length of stay in days (IQR)	5.0 (5.0)	5.0 (6.0)	0.76
PPM Insertion (%)	2/74 (3)	3/65 (5)	0.55
Changes made to cardiac medications (initiation/titration/cessation)	21/74 (28)	30/65 (46)	0.03
All-cause mortality	0 (0)	2 (3)	0.13
Cardio-pulmonary resuscitation	0 (0)	0 (0)	--
DC Cardioversion	0 (0)	0 (0)	--

Abstract

Background: Inappropriate cardiac telemetry use is associated with reduced patient flow and increased health care costs.

Aim: To evaluate the outcomes of guideline-based application of cardiac telemetry.

Methods: Phase I involved a prospective audit(03-09/2011) of telemetry use at a tertiary hospital. Data was collected on indication for telemetry and clinical outcomes. Phase II prospectively included patients > 18yrs under general medicine requiring ward based telemetry. As phase II occurred at a time remotely from phase I an audit similar to phase I(phase II – baseline) was completed prior to a three month intervention(05-08/2015). The intervention consisted of a daily telemetry ward round and an admission form based on the American Heart Association guidelines (class I telemetry indicated; class II: telemetry maybe indicated; class III, telemetry not indicated). Patient demographics, telemetry data and clinical outcomes were studied. Primary endpoint was the percentage reduction of class III indications while secondary endpoint included telemetry duration.

Results: In phase I(n=200), 38% were admitted with a class III indication resulting in no change in clinical management. 74 patients were included in phase II baseline(mean±SD age 73yrs ±14.9,57% male) whilst 65 patients were included in the intervention(mean±SD age 71yrs ±18.4,35% male). Both groups had similar baseline characteristics. There was a reduction in class III admissions post-intervention from 38% to 11%, $p<0.001$. Intervention was associated with a reduction in median telemetry duration (1.8 ± 1.8 vs 2.4 ± 2.5 days, $p=0.047$) however length of stay was similar in both groups ($p>0.05$).

Conclusion: Guideline based telemetry admissions and a regular telemetry ward round are associated with a reduction in inappropriate telemetry use.

Keywords – telemetry, arrhythmia, inpatient, guidelines

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Comparison of telemetry indications between Phase I and Phase II prior to intervention

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GUIDELINE-BASED INTERVENTION TO REDUCE TELEMETRY RATES IN A LARGE TERTIARY CENTRE

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