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Accurate Methods in Pulse Rate Assessment by Palpation: Pilot Study

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Honors Research Project

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Abstract

A person's pulse rate, which provides key data about physical and psychological health, must be assessed using a method that is both reliable and valid. Since no manual palpation standard exists, healthcare providers' assessment methods vary depending on count time (15, 30, or 60 seconds) and start points (zero or one). Some researchers have shown more accuracy when starting the count with "zero," but the common practice continues to be starting the count with "one." The purpose of this study is to be a pilot for pulse count method validation, specifically examining the effect of counting interval (15, 30, or 60 seconds), and comparing accuracy of pulse count started on "zero" versus "one." For each participant, the researchers palpated a radial pulse while counting for different time intervals, an electrocardiogram served as the gold standard comparison. Since pulse rate can vary substantially based on age, activity, health state, and other factors, the researchers assessed participants' pulses at rest and again when their pulse rate was faster; participants rode a stationary bike until their target heart rate for exercise was achieved. Through use of different counting intervals and start points ("zero" versus "one"), the researchers identified methods of assessment that are most accurate across a wide range of pulse rates. This pilot study enrolled healthy, young adults but paved the way for future research on accurate pulse rate assessment across age groups and disease states.

Keywords: pulse count, pulse assessment, radial pulse, vital signs

Accurate Methods in Pulse Rate Assessment by Palpation: Pilot Study

A person's pulse rate, which provides key data about physical and psychological health, must be assessed using a method that is both reliable and valid. Typically, pulse is counted for 15, 30, or 60 seconds and then multiplied to achieve pulse rate in beats per minute (bpm). Although there are many studies that focus on the accuracy of pulse rate based on counting interval, there is no standard. Additionally, pulse rate findings may vary based on starting the pulse count with either "zero" or "one." An early study by Hargest (1974) found that although people tend to begin pulse count with the first pulse being "one," it is more accurate for the first pulse to be "zero." This first pulse must not only be counted as "zero," but must also be the starting point for the time interval. There has been little research on the topic since Hargest's seminal work.

The purpose of this study was to serve as a pilot for pulse count method validation, specifically examining the effect of counting interval and pulse count started on "zero" versus "one." Participants' pulses were assessed at rest and then again when their pulse rate was tachycardic, achieved by exercising on a spinning bicycle. The tachycardic heart rate was used as a proxy for tachycardia due to intrinsic or pathologic patient factors, and to assess the difference in accuracy at a faster heart rate versus a normal rate. When assessed, the researchers counted for different time intervals starting at "zero" and then their findings were compared for verification against an electrocardiogram. Through use of different counting intervals and start points ("zero" versus "one"), the researcher identified which manual methods of assessment are most accurate in both normal and faster pulse rates. This pilot study enrolled young adults but paved the way for future research on accurate pulse rate assessment across a variety of ages and disease states.

Objectives

Research related to pulse assessment is limited and the most recent literature was published in 2017. A handful of researchers focused on the accuracy of manual pulse assessment within different populations (Jones, 1970; Hargest, 1974; Hollerbach & Sneed, 1990; Margolius et al., 1991; Sneed & Hollerbach, 1992; Sneed & Hollerbach, 1995; Hwu et al., 2000; Opio et al., 2017), but none have set a universally accepted standard. The research questions are focused on establishing three main conclusions: (1) should pulse count begin at the interval "one" or "zero"; (2) what interval should pulse count be assessed for (15-, 30-, or 60-seconds); and (3) are questions (1) and (2) influenced by heart rate – if the heart is in slower or faster rhythms.

Literature Review

Starting Point

In clinical practice, the majority of healthcare providers begin their pulse count with "one" instead of "zero" (Margolius, 1991; Sneed & Hollerbach, 1992; Sneed & Hollerbach, 1995). According to an early, informal study by Hargest (1970), when assessing pulse, the count should begin with "zero;" the first pulse marks the beginning of both the counting and timing intervals, then the examiner should continue with "one," "two," and so on. This method is similar to how years of life are counted. When a human is born, the count does not automatically begin at one, but instead once they have reached one full year cycle then the count is "one." Translating this to pulse count, Hargest explains that the count should begin with the first beat being "zero" since the heart must go through a full cardiac cycle between pulses to produce the proceeding pulse, so that second pulse is "one." Most researchers focus on evaluating the accuracy of different count intervals, and only a few mention the start number. Some who do include the start number in their studies agree with Hargest's starting count with "zero" method since the interval between palpable beats is the pulse interval being assessed (Hollerbach & Sneed, 1990; Hollerbach & Sneed, 1995), while others have completed studies that show beginning with the count interval "one" produces less error in pulse assessment (Yueh-Juen et al., 2000).

Counting Interval

Regarding time intervals in pulse assessment, there have been three separate suggested methods:

- Counting the pulse for 30 seconds and then multiplying by 2 to get the pulse per minute is most accurate when assessing pulses in sinus rhythm (Hollerbach & Sneed, 1990).
- As the pulse rate increases, counting for 15 seconds and multiplying by 4 becomes more inaccurate. Due to this inaccuracy, pulse rates with tachycardia should always be assessed for more than 15 seconds (Hollerbach & Sneed, 1990).
- Lastly, contrasting the prior two suggested methods, counting pulses at any rate for 60 seconds has no increased accuracy compared to counting for 15 or 30 seconds. (Margolius et al., 1991).

Additionally, when examining 15 seconds (x4) versus 30 seconds (x2) versus 60 seconds, the difference in accuracy may be due to mathematical factors. Meaning that multiplying a rate, which is a continuous measure, by an integer such as 4 or 2 may create inaccuracy. Also, the heart rate varies naturally over the course of a minute due to autonomic innervation or other influences, so inaccuracy when counting for less than 60 can occur (Kobayashi, 2013).

Understanding the difference between pulse rate and heart rate is also crucial. Heart rate is how many times a heart physically goes through the cardiac cycle of systole and diastole, while pulse rate is how many beats can be manually felt at an artery. Typically, heart rate and pulse rate are at a one-to-one ratio, but certain pathologies may alter this ratio, thus making the assessment of pulse rate and comparing to the heart rate important (Urden et al., 2022).

Gold Standard Comparison

To verify pulse count, the use of an electrocardiogram (ECG) instead of plethysmography (pulse oximetry) is best due to plethysmography showing an inaccurate representation of pulse. Not every heartbeat generates sufficient force to create a palpable peripheral pulsation. For example, when the heart contracts but there is no corresponding peripheral pulse by palpation, such as in atrial or ventricular premature contractions, a pulse deficit occurs. Deficits cause low-volume pulses that are undetectable by manual palpation. This creates an inaccurate representation of heart rate (Sneed & Hollerbach, 1995). When using an ECG to verify pulse count, the clinical professional operating the ECG is able to differentiate pulses and pulse deficits, thus giving an accurate representation of the pulse that should be palpable at a peripheral artery (Hollerbach & Sneed, 1992; Hollerbach & Sneed, 1995). Although ECGs are the current standard for pulse count verification, research is still limited, which warrants the question: what is the gold standard for manual pulse count verification?

One consistent and important conclusion is that further research is needed to evaluate the accuracy of different pulse assessment methods. See Appendix for further explanation of current published research regarding accuracy of pulse assessment.

Study Design

Participants and Sampling

Researchers sampled participants from an undergraduate university campus. Initial inclusion criteria were university athletes who were able to bike for enough time to increase their heart rate to a target heart rate specified by the American Heart Association. However, this was expanded to all university students because of the need for a larger sample size. Basic demographic data were recorded using a Qualtrics survey. Demographic data collected included gender at birth, athletic or sport participation, and year in school. Demographic data would have benefitted from including age since not all of our participants ended up being the traditional college students, aged 18-22 years.

Data Collection

The undergraduate nursing student researcher worked with an advance practice registered nurse (APRN) assistant to collect pulse data from palpation and ECGs at both resting and tachycardic heart rates. First, participants had their pulse assessed in a resting position (sitting in chair). This assessment was done by palpating the radial arterial pulse, and once the researcher was familiarized with the pulse, the minute-long assessment began. The researcher counted the radial pulse while the APRN assistant simultaneously printed an electrocardiogram to validate accuracy of pulse count. The researcher palpating counted aloud using the sequence "3, 2, 1, 0, 1, 2, 3…;" both the stopwatch and ECG printing were started when the researcher said "zero." This approach was done simultaneously to accurately match up the beginning of pulse count with heart rate and ECG reading. The investigators assessed together for 60 seconds, with the APRN assistant noting the count at 15, 30, and 60 seconds. The values recorded at 15 seconds were multiplied by 4 and the values at 30 seconds were multiplied by 2 to represent a full 60 second pulse rate. If any assessment errors were made, then the assessment was repeated for a full minute and those data were used instead.

To increase the participants' heart rate to a tachycardic pace, participants then exercised on stationary bikes until achieving the target heart rate recommended by the American Heart

Association, which for our population was in the 130s. The exercise pace and resistance were determined and adjusted by the participants to ensure safety. Once the target heart rate was reached, participants remained on the bike in a seated position and the pulse assessment was repeated as explained previously. Radial artery pulse assessment data were recorded on a spreadsheet and corresponding electrocardiograms were printed.

Safety Factors

For safety reasons, after reviewing two separate pulse intervals (one interval being at rest and the second being after bike exercise), the subject may have needed referral to a healthcare provider if the researchers identified any concerning abnormalities on the subject's ECG. This never occurred. An APRN was always present if medical intervention was needed.

Reliability and Validity

All equipment used and researchers involved were set up in the same location. The researchers conducted a practice data collection period where a practice participant was used to ensure simultaneous start times with pulse count, timer, and ECG recording; coordinating the researcher and assistant were necessary for reliability and validity of data collection. The right radial pulse was always used. Before beginning the manual pulse assessment, the researcher palpated the pulse for approximately 10 seconds to become acquainted with the pressure and speed of pulse of each participant. The same researchers reviewed ECGs and counted pulse every single time. These criteria were set in place to decrease any error or systemic differences between data collection sessions.

Results

Descriptive and inferential statistics were used to analyze data. Descriptive statistics were specifically used for demographic data. A two-way factorial ANOVA was used to evaluate the effect of start point ("zero" versus "one") and count time (15 versus 30 versus 60 seconds) on accuracy of manual pulse assessment. Lastly, paired sample *t*-tests were used to compare accuracy of manual pulse assessment methods to gold standard of ECG heart rate.

Demographics

The total sample size was comprised of 68 participants, 72.1% female and 27.9% male. In both resting and tachycardic measurements, average ECG pulse rates were higher among male participants (see Table 1). The participant pool was spread among classes: freshmen (22.1%), sophomores (20.6%), juniors (22.1%), and seniors (35.3%). Student participating in organized collegiate athletics comprised 48.5% of participants.

Table 1

Resting and Tachycardic Heart Rates

Heart rate	Gender at birth	*n*	*M*	*SD*	*SEM*
Resting	Female	49	77.14	14.968	2.138
	Male	19	78.16	13.805	3.167
Tachycardic	Female	49	107.12	18.730	2.676
	Male	19	110.16	16.156	3.707

Effects of Different Measuring Times and Starting Count Points

Overall mean differences between manual pulse assessments, no matter the count time (15, 30, or 60 seconds), were lower when starting at the count interval zero. When beginning count at zero, the mean difference between manual and ECG readings only differed slightly between 15 (-0.43 beats), 30 (-0.40 beats), and 60 (0.42 beats) seconds. The tachycardic pulse rate means at 15 and 30 seconds were not accurate since participants heart rates dropped rapidly once the participant stopped pedaling and the manual pulse assessment began, so the mean differences do not accurately represent the accuracy of manual assessment. Tachycardic manual assessment for 60 second count time shows a mean difference of 1.15 beats when starting at zero and 2.10 beats when starting at one, which once again shows starting at zero is more accurate.

As seen in Table 2, the two-way factorial ANOVA showed the main effect of both start point ("zero" versus "one") (F (1, 67) = 2171.56, p = 0.00) and count time (15 versus 30 versus 60 seconds) (F (1, 67) = 4.32, p = 0.02) were statistically significant. A significant interaction effect (F (1, 67) = 581.615, p = 0.00) also indicates the effect of count time on manual pulse assessment accuracy depends on start point. This means using different count times will result in statistically different levels of accuracy.

Table 2

Summary of Two-Way Factorial ANOVA

Source of variance	*SS*	*MS*	*df*	*F*
Count Time (A)	58.49	39.96	1.46	4.32*
Start Point (B)	532.245	532.245	1	2171.56**
A x B	148.26	148.26	1	581.62**

*p <.05. **p <.001.

As seen in Table 3 the paired sample t-tests showed no significant difference in the following manual assessment methods:

- Start point "zero" & count time 15 seconds, t (67) = -1.05, p = 0.30
- Start point "zero" & count time 30 seconds, t (67) = -1.72, p = 0.09

Focus was put on the methods that did not show a statistical significance in difference because that indicated the methods were not statistically significant in difference from the ECG mean.

Table 3

Paired Sample t-Tests Comparing Assessment of Resting Pulse Rates to ECG

Start point	Count time	Mean difference (*SD*)	*t*
0	15 seconds (x4)	-0.43 (3.34)	-1.05
	30 seconds (x2)	-0.40 (1.90)	-1.72
	60 seconds	0.43 (1.34)	2.62*
1	15 seconds (x4)	3.46 (3.53)	8.06**
	30 seconds (x2)	1.60 (1.90)	6.95**
	60 seconds	1.40 (1.46)	7.91**

*p <.05. **p <.001.

Discussion

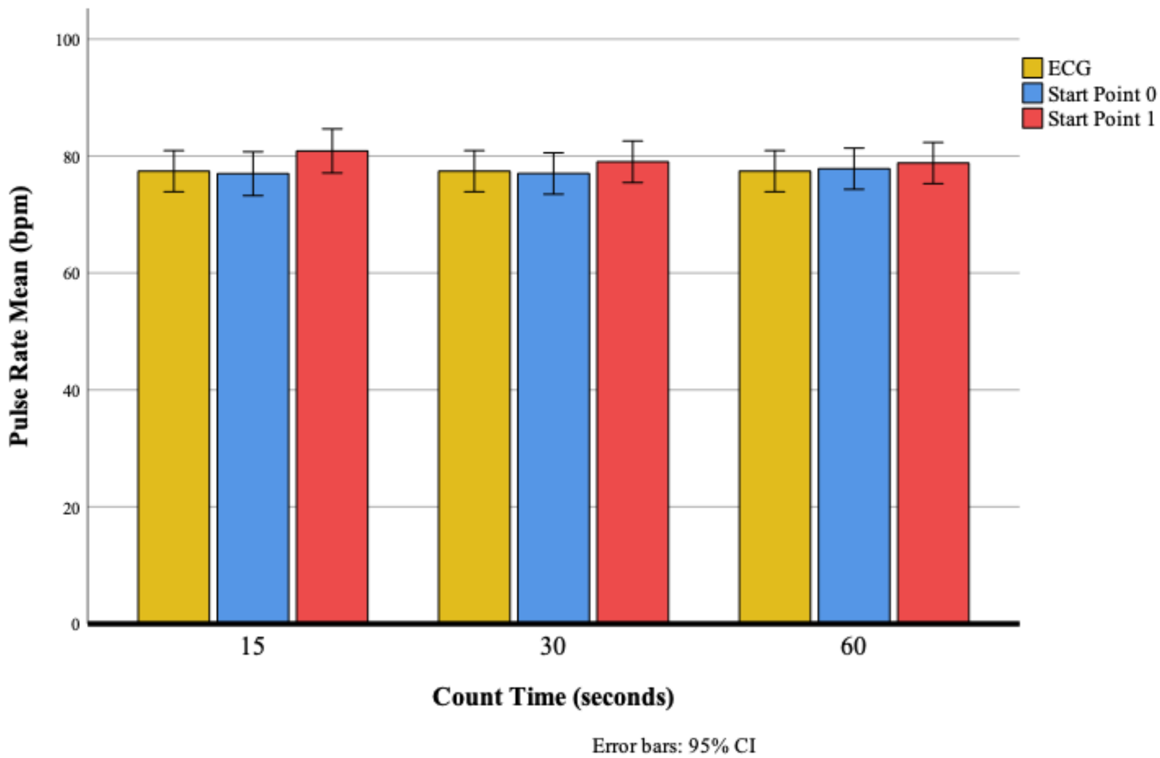
When evaluating the use of different manual pulse assessment methods, the ECG heart rate values were used as the gold standard. When the difference between manual assessment pulse values and ECG pulse values were negative, it indicated a lower pulse than on the ECG reading. When the difference between manual assessment pulse values and ECG pulse values was positive, it indicated a higher pulse than on the ECG reading. The data showed using the start point “zero” created a significantly lower absolute mean difference from the ECG value than using “one” as a start point.

Using the start point “one” always created statistically significant differences between manual palpation and ECG assessment, no matter which count time was used. Using start point “zero” and counting for 15 and 30 seconds did not create statically significant differences, thus indicating accuracy. So, pulses can be assessed accurately in a shorter amount of time than 60 seconds. Lastly, when using start point “zero” and count time 60 seconds, there was a statistically significant difference between manual palpation and ECG assessment.

When applying findings to clinical practice, thinking about clinical significance is also important. The average mean difference that is produced when using zero as the start point and 60 seconds as count time is 0.30 beats. So, although this is statistically significant in difference, there is likely no clinical significance. All these findings can be visualized in Figure 1.

Figure 1

Comparison of ECG to Manual Assessment Using Resting Pulse



Note. The gold bars represent the ECG gold standard, the blue bars represent start point “zero,” and the red bars represent start point “one.”

Limitations

Since the study was a pilot, a small and homogenous sample population limits generalizability. When collecting demographic data, although age was not collected, the overwhelming majority of students progressed directly from high school to college (likely between ages 18-22 years) and appeared in good health. Researchers also noted no abnormal heart rhythms or abnormal beats. There is a potential for inaccuracy since two people needed to coordinate to begin assessment on the exact same 60-second interval. Additionally, since researchers sampled almost exclusively young adults on a campus with primarily traditional students, participants' heart rates fell below a tachycardic rate very quickly, so the "tachycardic" pulse counts for 15 seconds (x4) and 30 seconds (x2) were markedly different from the 60 second reading per ECG.

Future Research

Clinicians typically start the pulse count based on a clock, not on the timing of a pulse beat. In other words, the examiner starts counting when a clock or wristwatch signals a logical time to start, whereas researchers in this study started a stopwatch based on the pulse count timing. Future research should consider how methods with a single examiner in the clinical setting may be different from methods used in a research setting.

To improve generalizability, future studies should include people with a variety of health states (especially with variation in heart rate and rhythm) as well as different age groups. This use of wider patient populations would enable researchers to generalize data. Finally, researchers should also seek to define what is clinically significant or relevant regarding pulse assessment mean difference from the gold standard ECG.

Conclusion

The mean difference between manual pulse assessment and ECG palpation standard was consistently used to represent the accuracy of manual pulse assessment. Using the start point of "zero" consistently created less inaccuracy, no matter which count time was being used. When using both the start point "zero" and count time 15 seconds, no statical significance was shown in the means of pulse values, so using those conditions to assess resting heart rate is most accurate.

Although the count time 60 seconds with start point "zero" produced statistically significant differences between means, the difference was 0.42 beats for 60 seconds, so the significance is most likely too minimal to be clinically relevant.

These results can be used to inform future nursing and medical assessment textbooks about the most accurate way to assess pulse. Based on the results of this pilot study, the researcher recommends a regular pulse at a resting rate can be assessed accurately by counting for just 15 or 30 seconds, a practice which would allow health care professionals to save time and effort on pulse assessment without fear of inaccuracy. Furthermore, when assessing pulse, the first beat palpated should be counted as "zero." These recommendations are made with caution since these findings are under perfect, research conditions. So, further research in clinical settings is warranted in order to allow generalization of findings to all patient populations and before beginning widespread change in clinical practice.

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Appendix A

Literature Review: Summary of Aims, Findings, and Limitations

Author	Title	Aim	Findings	Limitations
Jones, 1970	"Accuracy of Pulse Rates Counted for Fifteen, Thirty, and Sixty Seconds"	Assess the accuracy of pulse rate obtained by nurses when palpating the radial pulse by comparing them to electrocardiogram heart rates.	Graduate nurses were significantly more accurate than student nurses. Significant differences were found when using different time intervals to assess pulse. The accuracy decreased as the count time interval increased. Inaccuracy was found to be higher when the heart rate of subjects was higher. There is no difference between using the left or right wrist for radial pulse assessment	Inaccuracy of synchronizing the pulse count with the ECG recording. By using the same minute for three different pulse counts there was an increase in inaccuracy as the time interval increased since the heart rate of the subject decreased post-exercise.
Hargest, 1974	"Start Your Count with Zero"	Evaluate difference in error in regard to beginning pulse assessment with start interval "one" or "zero."	Manual pulse assessment should begin with starting count at "0". Compared to the idea of "child does not become a year old at birth, but 12 months from birth."	The study was conducted informally.
Hollerbach & Sneed, 1990	"Accuracy of Radial Pulse Assessment by Length of Counting Interval"	Determine the accuracy of resting and rapid pulse assessment in regard to time interval (15-, 30-, and 60-seconds).	Rapid heart rates were significantly less accurate than resting rates. 15-second rapid heart rate count was most significantly different from all of the counts done with a resting heart rate.	The subjects used for pulses were healthy, so the findings cannot be generalized to all patient populations.

			30-second counts are most accurate and efficient for manually assessing pulse rate. 15-second count should not be used with rapid heart rates due to inaccuracy. No significant difference was found in regard to accuracy when looking the years of expertise of the pulse assessors.	Cannot rule out variation between manual palpation and ECG recordings due to dissociation. This can be minimized by the use of both ECGs and plethysmograph recordings to ensure accuracy.
Margolius et al., 1991	"Accuracy of Apical Pulse Rate Measurement in Young Children"	Determine if accuracy of pulse rate assessment is influenced by child's awake or asleep state as well as by length of counting interval (15-, 30-, and 60-seconds).	73% of subjects stated they begin their pulse count with "one." Counting pulses at any rate for 60 second has the most *inaccuracy* compared to counting for 15 or 30 seconds.	Pulses that were used were all pediatric, so cannot generalize to adult population.
Sneed & Hollerbach, 1992	"Accuracy of heart rate assessment in atrial fibrillation"	Determine the most accurate heart rate assessment methods in patients with atrial fibrillation based on counting intervals (15-, 30-, and 60-seconds) and pulse location (apical and radial).	81% of subjects stated they begin pulse count with "one." Apical location of pulse assessment was more accurate. 60-second counting interval was significantly more accurate regardless of pulse assessment location. Nurses with the most education and expertise were the least accurate with pulse assessment, showing that pulse	The only pulse rate used was that of a healthy individual with atrial fibrillation, so findings cannot be generalized to all acutely ill patients.

			assessment accuracy depends on the assessor's current frequency of using the skill instead of their overall education and expertise.	
Sneed & Hollerbach, 1995	"Measurement Error in Counting Heart Rate: Potential Sources and Solutions"	Summarize the potential sources of measurement error in counting heart rate and solutions based on past studies.	Sources of error include the heart rate, rhythm, and volume. Rates over 90 bpm tend to be undercounted no matter the rhythm. 60-second counting interval tends to be most accurate, but the statistical difference seen with 15- and 30-second counts is probably not clinically significant. Majority of nurses begin their count with "one" instead of "zero," which causes overestimation of pulse. Counting apical heart rate for 60-seconds will always be most accurate method of pulse assessment. Shorter counting intervals are accurate enough to be used when assessment a stable patient or when completing frequent assessment after an accurate baseline is attained. Nursing students should be taught to begin their	None stated

			count with “zero” rather than “one” to minimize systemic overestimation of pulse.	
Hwu et al., 2000	“A study of the effectiveness of different measuring times and counting methods of human radial pulse rates”	Determine the accuracy of different resting pulse assessments methods based on measuring times (15-,30-,60-seconds) and start interval (“one” and “zero”).	Beginning pulse count with “one” rather than “zero” yields most accurate results. When beginning pulse count with “one,” rates obtained when counting for 15- or 30-seconds can be used to estimate 60-second resting pulse rates.	Healthy individuals were used as the pulse for all measures, so generalizations to all patient populations should not be made.
Opio et al., 2017	“How Well Are Pulses Measured? Practice-Based Evidence from an Observational Study of Acutely Ill Medical Patients During Hospital Admission”	Observation study aimed to find how accuracy and precision of pulse assessment is influenced by rate, rhythm, and blood pressure.	Within the acutely ill patient population, pulse assessments are inaccurate when compared to ECG readings, so radial pulses should not be used to assess the heart rates of acutely ill patients.	Researchers conducted a retrospective chart audit, so data collector may not have been consistent due to lack of expertise and experience.