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Brief Report

Impact of patient and environmental factors on capillary refill time in adults

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Abstract

Objectives: Capillary refill time (CRT) has been taught as a rapid indicator of circulatory status. The aim of this study was to define normal CRT in the Australian context and the environmental, patient, and drug factors that influence it.

Methods: This prospective observational study included healthy adults at hospital clinics, workplaces, universities, and community groups. Volunteer participants provided their age, sex, ethnic group, and use of hypertensive or cardiac medications. Capillary refill time, ambient temperature, and patient temperature were recorded in a standard manner. Data were analyzed using descriptive statistics and regression analyses. The 95th percentile was used to define the upper limit of normal.

Results: One thousand participants were included; 57% were women, 90% were white, and 21% were taking cardiac medications.The median CRT was 1.9 seconds (95th percentile, 3.5 seconds). The CRT increased 3.3% for each additional decade of age. The CRT was also on average 7% lower in men than in women. The CRT decreased by 1.2% per degree-Celsius rise of ambient temperature, independently of patient's temperature, and decreased by 5% for each degree-Celsius rise in patient temperature, independently of ambient temperature. On multivariant analysis, age, sex, ambient temperature, and patient temperature were statistically significant predictors of CRT, but together explain only 8% of the observed variability.

Conclusion: Capillary refill time varies with environmental and patient factors, but these account for only a small proportion of the variability observed. Its suitability as a reliable clinical test is doubtful.

1. Introduction

Capillary refill time (CRT) has been taught as a rapid indicator of circulatory status. Normal CRT has usually been regarded as less than 2 seconds [1,2]. However, there is considerable debate in the literature as to the definition of a normal CRT and the factors that may influence it.

Schriger and Baraff [3] reported that CRT was age and sex dependent, finding that children and adult men had significantly shorter CRT than adult women and elderly men and women. They advocated definition of the upper limit of normal for women as 3 seconds and for the

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elderly as 4 seconds. Watson and Kelly [4] confirmed that CRT varies significantly with age, sex, and environmental temperature.

In addition to these factors, it makes physiological sense that patient temperature and vasoactive medications might also impact CRT. No data defining normal CRT in the Australian population have been reported.

The aim of this study is to define normal CRT in the Australian context and the impact of defined environmental, patient, and drug factors on it.

2. Methods

This prospective, observational cohort study of healthy adult volunteers was undertaken at several sites including musculoskeletal outpatient clinics at a hospital, workplaces, universities, and local community groups. Inclusion criteria for this study were age older than 18 years, provision of verbal consent, and functioning independently in the community. Exclusion criterion was the inability to communicate in English and unavailability of a suitable translator.

The study period was from June 7, 2006, to September 9, 2006. Data collected included self-report of age (in 10-year bands), sex, ethnic group, and use of either *hypertensive or cardiac medications* (defined as drugs for treatment of hypertension, β-blockers, and angiotensin-converting enzyme inhibitors but not including aspirin, warfarin, or frusemide). Participant's temperature was measured using a tympanic thermometer that had been calibrated using standard procedures. Ambient temperature was measured using a commercially available thermometer.

A single researcher (BA) measured each participant's CRT twice, 1 minute apart. The participant's right index finger was blanched using 5 seconds of moderate pressure, and the length of time required for the return of normal color was measured with a stopwatch. Where the right index finger was unsuitable, either the left index finger or right middle finger was used as an alternative. The average of the 2 readings was taken as the true value.

The primary outcomes of interest were the median and upper limit of normal CRT, with the upper limit of normal defined by the 95th percentile of CRT. Secondary outcomes were the impact of patient (age, sex, temperature), environmental (temperature), and drug (cardiac or antihypertensive medications) factors on CRT and the performance of the published cutoffs for normal CRT in our population.

Data were analyzed using descriptive statistics, log transformation, and regression analyses. Given the potential subjectivity of CRT, it was decided to use the average of the 2 readings for analysis. Capillary refill time measurement was not normally distributed. Log transformation of the average CRT provided data that fulfilled the criteria for normality and that were used for subsequent data analysis. The study was approved by the relevant human research ethics committees.

3. Results

Data were collected from 1000 participants. The median age fell in the 40- to 49-year-old age band, and the greatest percentage of participants (38%) was in the 18- to 29-year-old age band. There were no participants older than 90 years. There were more women (58%) in the study than men, and 90% of the sample was of white ethnicity.

Cardiac medications were taken by 213 (21%) of participants. Patient body temperature ranged from 34.3°C to 37.7°C, with a mean of 36.5°C (SD 0.5°C). Ambient temperature ranged from 14.3°C to 26.2°C, with a mean of 21.1°C (SD 2.1°C).

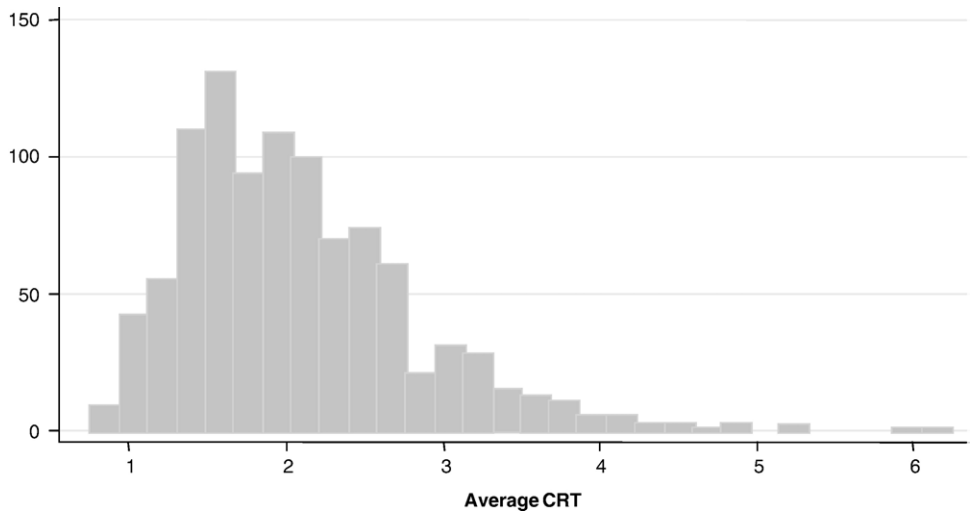

Fig. 1 Frequency distribution of CRT measurements.

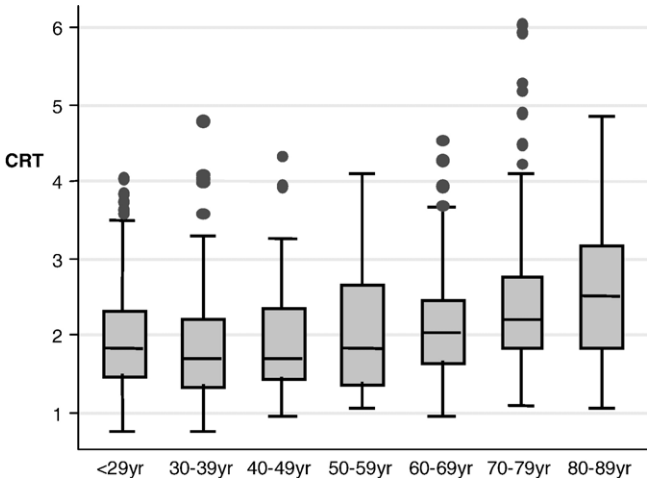

Fig. 2 The CRT distribution by age.

Capillary refill time ranged from 0.8 to 6.1 seconds, with an upper limit of normal (using the 95th percentile) of 3.5 seconds (95% confidence interval [CI], 3.4-3.7). The distribution of CRT is shown in Fig. 1.

After multivariate analysis, 4 predictor variables for CRT were found including age, sex, ambient temperature, and patient temperature. Capillary refill time differed significantly between age groups ($P \leq .001$) as shown in Fig. 2 and on average increased by 3.3% per decade of age (95% CI, 2.2%-4.4%). Capillary refill time was on average 7% lower in men than in women (95% CI, rise 3% to 12%) and decreased by 1.2% per degree Celsius of ambient temperature (95% CI, 0%-2.8%) independent of patient temperature. For each 1°C decrease in patient temperature, CRT increased by 5% (95% CI, 1%-10%), independently of ambient temperature. Ethnic group and use of cardiac or antihypertensive medication did not retain a statistically significant relationship with CRT. Taken together, age, sex, ambient temperature, and patient temperature explained only 8% of the observed variability.

With respect to reproducibility, the mean difference in CRT was −0.1 second (95% CI, −0.1 to 0.0), which means that the second CRT measurement tended to be shorter than the first CRT measurement by 0.1 second. Although this result is statistically significant, it is unlikely to be clinically significant. The 95% limits of agreement were −0.7 to 0.6 second.

Using 2.0 seconds as the upper limit of normal would have misclassified 45% of participants in this study. The age- and sex-defined limits defined by Schriger and Baraff [3] would have misclassified 19% of adults and 5% of the elderly.

4. Discussion

Capillary refill time has been advocated for rapid assessment of circulatory status. However, the reliability of the test had been questioned because of the absence of agreed ranges for normal CRT values in a healthy adult population [3,4]. In this study, we have defined the reference range for adult Australians and have investigated some of the factors that contribute to variability in the measurements.

Capillary refill time ranged from 0.8 to 6.1 seconds; and the upper limit of normal overall, defined by the 95th percentile, was 3.5 seconds. The 95th percentile was found to be strongly dependent on age, sex, ambient temperature, and patient temperature. This coupled with the fact that it would have misclassified 45% of our healthy volunteers provides further evidence that the 2-second upper limit of normal advocated by Champion et al [1,2] is inappropriate. Two previous studies have investigated the "normal" range of CRTs in healthy adult volunteers, also finding the 2-second definition inaccurate [3,4].

The previous studies [3,4] reported lower medians and 95th percentiles for CRT for each age and sex group than those obtained in this study. Reasons for this may include differences in ambient temperatures; differences in the general health, ethnicity, or age distributions of the population; and the subjectivity of the test.

Capillary refill time in this study was affected significantly by age; this is consistent with 2 previous studies [3,4] that reported the upper limit of normal for those older than 60 years as 4.5 and 3.8 seconds, respectively.

The findings that CRT varies with age and sex make a case for different normal cutoffs based on these features. This was the approach taken by Schriger and Baraff [3]. Our study found that age and sex accounted for only a small proportion of variability of CRT measurement, and a large proportion of our sample (25%) would have been misclassified with the use of this technique. Multiple cutoffs may also prove difficult for clinicians to remember.

Previous studies concur that CRT is affected significantly by ambient temperature [4,5]. Before this study, there were no reports of participant temperature contributing significantly to CRT. This study found a statistically significant relationship between CRT and participant temperature. Capillary refill time was on average 5% lower for each 1°C increase in tympanic temperature. Although this relationship was statistically significant ($P = .026$), it is unlikely to be significant clinically because of the scale of the measurement, the narrow range of patient temperatures, and the variability of CRT in the population.

This was the first study to investigate the relationship between CRT and ethnicity and use of cardiac medications. Although there may be a theoretical basis for CRT differences due to these factors, we found no independent relationship between them and CRT.

Age, sex, ambient temperature, and participant temperature accounted for only 8% of the variability in CRT values obtained in this study. Previous studies have also

had similar findings [3,4]. These findings imply that there are undiscovered factors that introduce variability in CRT measurement.

Taken together, the available evidence seriously challenges the utility of CRT given the wide variation in normal and multiple modifying factors that are difficult or impossible to control or adjust for.

This study has some limitations that should be considered when interpreting the results. Demographic data were by self-report and may be inaccurate. Capillary refill time was collected by a single researcher. Although this controls for technique variation, it may have introduced other biases because she was obviously not blinded to her first estimate of CRT when taking the second measurement. Determining the end point of CRT estimation can be difficult. Using a single observer goes some way to address this. Sample characteristics such as age and sex distribution and environmental conditions impacted the results. It is hoped that the size of the sample minimized any undue bias.

5. Conclusion

Capillary refill time varies with environmental and patient factors, but these account for only a small proportion of the variability observed. Its suitability as a reliable clinical test is doubtful.

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