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The Power of Flash Mob Research

Conducting a Nationwide Observational Clinical Study on Capillary Refill Time in a Single Day

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Study Group*

BACKGROUND: Capillary refill time (CRT) is a clinical test used to evaluate the circulatory status of patients; various methods are available to assess CRT. Conventional clinical research often demands large numbers of patients, making it costly, labor-intensive, and time-consuming. We studied the interobserver agreement on CRT in a nationwide study by using a novel method of research called flash mob research (FMR).

METHODS: Physicians in the Netherlands were recruited by using word-of-mouth referrals, conventional media, and social media to participate in a nationwide, single-day, "nine-to-five," multicenter, cross-sectional, observational study to evaluate CRT. Patients aged ≥ 18 years presenting to the ED or who were hospitalized were eligible for inclusion. CRT was measured independently (by two investigators) at the patient's sternum and distal phalanx after application of pressure for 5 s (5s) and 15 s (15s).

RESULTS: On October 29, 2014, a total of 458 investigators in 38 Dutch hospitals enrolled 1,734 patients. The mean CRT measured at the distal phalanx were 2.3 s (5s, SD 1.1) and 2.4 s (15s, SD 1.3). The mean CRT measured at the sternum was 2.6 s (5s, SD 1.1) and 2.7 s (15s, SD 1.1). Interobserver agreement was higher for the distal phalanx (κ value, 0.40) than for the sternum (κ value, 0.30).

CONCLUSIONS: Interobserver agreement on CRT is, at best, moderate. CRT measured at the distal phalanx yielded higher interobserver agreement compared with sternal CRT measurements. FMR proved a valuable instrument to investigate a relatively simple clinical question in an inexpensive, quick, and reliable manner.   CHEST 2017; 151(5):1106-1113

KEY WORDS: biomedical research; capillary refill time; data collection; physiology

Evidence assessing the usefulness and reliability of commonly used bedside diagnostic tests is not always available or easily obtained. Capillary refill time (CRT) is frequently used to judge a patient's circulatory status; a prolonged CRT is believed to be associated with an inadequate perfusion.[1,2] Despite few outcome data to support the use of CRT in adults outside of the ICU, the use of CRT is widespread.[3-5] CRT is a standard part of rapid primary assessment of critically ill patients in various advanced life support guidelines.[2,6]

Originally, CRT was defined without strict time limits (as "normal," "definite slowing," and "very sluggish"[7]), which left room for subjective interpretation, making reproducibility difficult. In the 1980s, an operational definition of 2 s as the upper limit of a normal CRT was recommended, which was replaced in 1988 with the less used upper limits of normal adjusted for age and sex.[1,8] Despite these recommendations, the measurement and interpretation of CRT remain inconsistent.[9,10] CRT is measured at different sites and with different pressure times. In adult ICU settings, application of pressure at the fingertip for 15 s is considered the standard; in children, CRT is mostly measured at the sternum.[5,10-12] Interpretation is hindered by ambient and patient factors that are not always easy to control (eg, ambient temperature, light, patient peripheral temperature).[2,13-16] Even in controlled circumstances, the interobserver reliability of CRT measurements has been questioned.[2,11,17-19] In addition, the various methods to measure CRT have never been compared in adults.

CRT is used in daily clinical practice worldwide, but it remains questionable which method should be used to measure CRT (sternum or phalanx) and whether the results are reproducible. The present study was therefore designed to compare the most frequently used methods to measure CRT in adult patients with variable hemodynamic status; the study setting resembled daily practice to determine which measurement has the highest interobserver agreement and to determine if the sternum and distal phalanx measurements can be used interchangeably.

Conventional clinical research used for answering clinically oriented research questions often demands large numbers of patients, making it costly, labor-intensive, and time-consuming. We saw a possible solution in flash mob research (FMR). This technique is a novel method of organizing research and allows the investigation of clinically relevant questions on a large scale in an abbreviated time course.[20] FMR is based on the concept of flash mobs: "a sudden and planned gathering of many people at a particular place that has been arranged earlier on an internet website."[21] Using the numerical strength of multiple hospitals, as well as the professional and social networks of their medical staff, it is possible to obtain sufficient data with FMR in a short time course[20] while upholding the same quality standards.

The primary objective of the present study was to determine the interobserver agreement of CRT measurements as measured at the sternum and at the distal phalanx using pressure times of 5 and 15 s and to relate the measurements with hemodynamic characteristics. Our secondary aim was to establish the feasibility of using FMR as a fast, inexpensive, and robust method to investigate clinical questions by using the power of social networks and new and conventional media to gather as many relevant data as possible in a short period of time.

Patients and Methods
Study Design
This trial was a nationwide, single-day, "nine-to-five," multicenter, cross-sectional observational study.

Setting up an FMR
As in flash mobs, preparations for FMR were made in a small group. The research question and study design were conceived in the Erasmus University Medical Center (EMCR) in Rotterdam, the Netherlands. The EMCR acted as coordination center for the duration of the study.

A steering committee with members from all of the Netherlands further elaborated the research question and study protocol. The protocol was approved by the medical ethics committee of the EMCR. Members of the steering committee invited physicians from their professional networks from all eight Dutch university hospitals, and subsequently physicians from affiliated regional hospitals, to participate; the result was nationwide participation. In each participating hospital, a local investigator, designated the "ambassador," coordinated the study; ambassadors were either medical specialists or residents. Ambassadors obtained local ethical board approval of the protocol,

recruited and instructed investigators, and were responsible for handling data. Similar to flash mobs, communication with participating investigators, public, and peers was mainly conducted by using e-mail, social media, and our Website.

Setting, Patients, and Variables

On October 29, 2014, between 9:00 AM and 5:00 PM, data were simultaneously collected in all participating hospitals. Patients aged $\geq$ 18 years who were able to provide informed consent and who presented to the ED or were hospitalized within this period were eligible for enrollment.

After providing consent, patients were examined independently by two investigators working within a 5-min interval. Investigators were physicians (medical specialists or residents), nurses, and medical students in their clinical rotations. Investigators were instructed on (and worked according to) standard operating procedures, which described the order of the tests. Investigators measured CRT at two sites twice: the sternum (CRTs) and the distal phalanx of the finger (CRTp). The first measurement occurred after application of pressure for 5 s (CRTs$_5$ and CRTp$_5$, respectively), and the second after application of pressure for 15 s (CRTs$_{15}$ and CRTp$_{15}$). CRTp was measured by applying sufficient pressure at the distal phalanx of the finger with the hand held at heart level to cause blanching of the skin, and CRT was defined as the time necessary for the skin to regain its color.[1] CRTs were measured by applying sufficient pressure to achieve blanching of the skin of the sternum, and again CRT was defined as the time necessary for the skin to regain its color. Investigators were advised to determine CRT by counting, and no timing devices were advised, mimicking daily practice. CRT was measured in seconds, and the results were rounded off to the nearest half-second. This resolution allowed categorization of the outcome by using upper values of normal as suggested in other studies[1,5,8]; this method was previously used by Anderson et al.[17]

Investigators subjectively assessed the peripheral temperature by placing the back of the hand on the patients' hand (cold vs not cold). Investigators provided their subjective conclusion of the patient's hemodynamic status (adequate vs inadequate) using all available clinical information. Investigators also provided their subjective conclusion of the observed CRT (normal vs prolonged), without predefining normality. The subjective conclusion was chosen to resemble daily practice, as clinicians often present measured CRT with a dichotomous outcome. Pulse rate, blood pressure, respiratory rate, temperature, and oxygen saturation were measured by using local standard procedures. All data were entered into local databases, which were subsequently combined at the EMCR. All patients with CRT measured by two investigators were included in the final analysis.

Mean arterial pressure (MAP) was calculated and dichotomized (< 65 mm Hg vs ≥ 65 mm Hg). MAP < 65 mm Hg was considered inadequate.[22] Pulse rate was categorized into one of the following three groups: < 60 beats/min, 60 to 100 beats/min, and > 100 beats/min. CRT was categorized by using definitions found in the literature. CRTs$_5$ and CRTp$_5$ were categorized using the upper limits of normal (2.0 s) as defined by Champion et al[8] and the age and sex adjusted upper values of normal (male subjects, aged < 62 years: CRTs$_5$ and CRTp$_5$ 2.0 s; female subjects, aged < 62 years: CRTs$_5$ and CRTp$_5$ 3.0 s; male and female subjects aged ≥ 62 years: CRTs$_5$ and CRTp$_5$ 4.0 s) as defined by Schriger and Baraff.[1] For CRTs$_{15}$ and CRTp$_{15}$, an upper limit of normal of 4.0 s was used.[5]

Study Size

The study size could not be predicted due to the FMR design. In principle, a successful FMR should include a large sample size for reliable conclusions.

Statistical Methods

Data were summarized in terms of mean, median, 95% CIs, and SD when appropriate. Categorical data were analyzed by using χ^2 tests. The means of two groups were compared by using the Student t test (normal distribution) or the Mann-Whitney U test (nonnormal distribution); the means of three groups were compared by using the Kruskal-Wallis test. Differences between continuous data with nonnormal distribution were analyzed by using Wilcoxon signed-rank sum tests. Interobserver agreement was analyzed for discrete values of CRT by using the intraclass correlation coefficient. In addition, interobserver agreement was analyzed for categorical values of CRT by using κ statistics. The variation of CRT with age and sex was analyzed with the use of linear regression. Missing data were considered missing at random and were therefore ignored. A difference of 0.5 s between CRTs and CRTp was considered clinically relevant.[10,17]

A P value $< .05$ was considered statistically significant. Statistical analyses were performed by using SPSS version 21.0 (IBM SPSS Statistics, IBM Corporation).

Results

Participating Hospitals

A total of 38 hospitals, located all over the Netherlands, participated in the study (representing 45% of the total number of 85 Dutch hospital organizations); this total included all eight university hospitals, 29 teaching hospitals (56% of nonacademic teaching hospitals), and one nonteaching hospital. Mean inclusion was 46 patients per hospital (median, 39; range, 3-130). Of the participating hospitals, almost 40% provided data within 24 h and 76% within 1 week. All data were available within 19 days.

Participating Investigators

A total of 458 investigators participated in the study (33 medical specialists, 246 residents, 122 medical students, and 57 nurses). The mean number of enrollments was seven patients per investigator (range, 1-65). Most enrollments were done by residents (n = 1,916; mean, 8), followed by medical students (n = 1,096; mean, 9), medical specialists (n = 288; mean, 9), and nurses (n = 168; mean, 3).

Patient Characteristics

A total of 1,734 patients (3,468 examinations) were included in the study, with a slight preponderance of male subjects (51.6%; n = 894). Patients overall had a mean age of 65 years. The majority (78.1%) were inpatients. Patient characteristics are presented in Table 1.

Capillary Refill Time

The mean peripheral CRT was 2.3 s (CRTp$_5$, SD 1.1) and 2.4 s (CRTp$_{15}$, SD 1.3) and mean sternal CRT was

TABLE 1] Patient Characteristics

Characteristic	Male (n = 894 [51.6%])	Female (n = 840 [48.4%])	Total (N = 1,734)
Age,[a] y (n = 1,734)	65 ± 16	65 ± 18	65 ± 17
Systolic blood pressure,[a] mm Hg (n = 1,728)	131 ± 21	133 ± 23	132 ± 22
Diastolic blood pressure,[b] mm Hg (n = 1,728)	75 ± 12	72 ± 13	173 ± 13
Mean arterial pressure[a] (n = 1,728)	93 ± 14	92 ± 14	93 ± 14
Pulse,[c] frequency/min (n = 1,731)	79 ± 16	81 ± 16	80 ± 16
Oxygen saturation in percentage[a] (n = 1,628)	96 ± 3	96 ± 3	96 ± 3
Respiratory rate,[a] breaths/min (n = 1,598)	17 ± 4	16 ± 4	17 ± 4
Temperature,[b] °C (n = 1,723)	36.8 ± 0.7	36.9 ± 0.7	36.9 ± 0.7

Data are expressed as mean ± SD.
[a]Not significant.
[b]$P < .001$.
[c]$P = .008$.

2.6 s (CRTs$_5$, SD 1.1) and 2.7 s (CRTs$_{15}$, SD 1.1). CRTp$_5$ was shorter in women (2.2 s, SD 1.0) than in men (2.4 s, SD 1.2; $P = .006$) and increased with age (0.16 s per 10 years; $P < .001$) (Fig 1). On average, CRTp$_5$ was 0.3 s shorter than CRTs$_5$ ($P < .001$), and CRTp$_{15}$ was 0.3 s shorter than CRTs$_{15}$ ($P < .001$). CRT correlated positively with MAP, subjective peripheral temperature, and subjective assessment of the hemodynamic status. There was no correlation with pulse rate (Table 2).
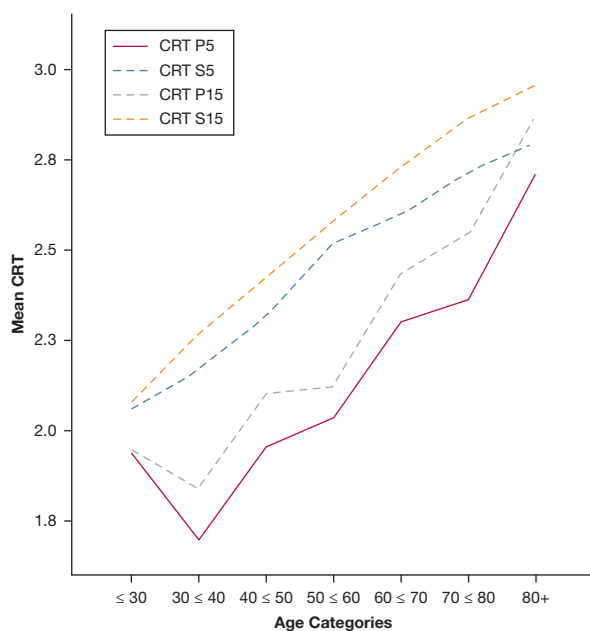

Figure 1 – Mean CRT in seconds for different age categories in years. CRT = capillary refill time; P5 = peripheral measurement after application of pressure for 5 s; P15 = peripheral measurement after application of pressure for seconds; S5 = sternal measurement after application of pressure for 5 s; S15 = sternal measurement after application of pressure for 15 s.

The mean difference between measurements of the first and second investigator was 0.1 s (CRTp$_5$, 0.1 s [95% CI, 0.0-0.1]; CRTp$_{15}$, 0.1 [95% CI, 0.0-0.1]; CRTs$_5$, 0.1 [95% CI, 0.0-0.1]; and CRTs$_{15}$, 0.1 [95% CI, 0.0-0.1]). The median difference was 0 s in all groups. Interobserver agreement, assessed by calculating the intraclass correlation coefficient between the CRTp measurements of both investigators, was 0.52 for CRTp$_5$ (95% CI, 0.49-0.56) and 0.54 for CRTp$_{15}$ (95% CI, 0.50-0.57) ($P < .001$), and interobserver agreement on measurements of CRTs was 0.43 for CRTs$_5$ (95% CI, 0.39-0.47) and 0.46 for CRTs$_{15}$ (95% CI, 0.42-0.49) ($P < .001$) (Table 3).

The agreement between the two investigators on whether the subjective CRT was normal or prolonged was assessed by using κ statistics. Application of pressure for 5 s yielded a κ value of 0.40 for CRTp (95% CI, 0.36-0.45) and 0.30 for CRTs (95% CI, 0.26-0.35) (both fair agreement)[23] when using 2 s as the upper value of normal, and a κ value of 0.20 for CRTp (95% CI, 0.12-0.29) and 0.13 for CRTs (95% CI, 0.04-0.22) (both slight agreement)[23] when using upper limits of normal based on age and sex. Using 4 s as the upper value of normal after application of 15 s of pressure yielded a κ value of 0.32 for CRTp measurements (95% CI, 0.24-0.41) and 0.23 for CRTs measurements (95% CI, 0.15-0.31) (both fair agreement). Agreement between two investigators on the subjective conclusion of whether the CRT was normal or prolonged yielded a κ value of 0.44 (95% CI, 0.37-0.51) (moderate agreement) (Table 4).[23]

Discussion

To our knowledge, our nationwide, single-day, nine-to-five, multicenter, cross-sectional observational study is the first to analyze the interobserver agreement of four

TABLE 2] Mean Capillary Refill Times

Parameter	CRTp$_5$	95% CI	CRTp$_{15}$	95% CI	CRTs$_5$	95% CI	CRTs$_{15}$	95% CI
Total	2.3	2.2-2.3	2.4	2.4-2.5	2.6	2.5-2.6	2.7	2.7-2.8
Subjective peripheral temperature								
Cold	3.2	3.0-3.4	3.3	3.1-3.6	2.9	2.5-2.6	3.0	2.9-3.2
Warm	2.1	2.1-2.2	2.3	2.2-2.3	2.5	2.8-3.1	2.6	2.6-2.7
P[a]	< .001		< .001		< .001		< .001	
Subjective hemodynamic status								
Inadequate	3.2	2.8-3.5	3.6	3.1- 4.2	3.2	2.9-3.5	3.5	3.2-3.8
Adequate	2.2	2.2-2.3	2.4	2.3-2.4	2.6	2.5-2.6	2.7	2.6-2.7
P[a]	< .001		< .001		< .001		< .001	
Mean arterial pressure, mm Hg								
< 65	3.0	2.6-3.5	3.3	2.7-3.9	3.4	2.7-4.1	3.6	3.0-4.2
≥ 65	2.3	2.2-2.3	2.4	2.3-2.5	2.6	2.5-2.6	2.7	2.6-2.7
P[a]	.001		< .001		.01		.002	
Pulse rate per minute								
< 60	2.3	2.1-2.5	2.6	2.3-2.9	2.6	2.5-2.9	2.8	2.5-3.0
60-100	2.3	2.2-2.3	2.4	2.3-2.5	2.6	2.5-2.6	2.7	2.6-2.8
> 100	2.2	2.0-2.4	2.4	2.2-2.6	2.6	2.4-2.7	2.7	2.5-2.9
P[b]	.407		.397		.800		.862	
Subjective conclusion of the CRT								
Prolonged	3.5	3.3-3.7	3.9	3.6-4.1	3.6	3.4-3.7	3.8	3.6-4.0
Normal	2.1	2.1-2.1	2.2	2.2-2.3	2.5	2.4-2.5	2.6	2.5-2.6
P[a]	< .001		< .001		< .001		< .001	
Temperature, °C								
< 36	2.6	2.4-2.9	2.8	2.6-3.1	2.6	2.4-2.8	2.8	2.5-3.0
36-38	2.3	2.2-2.3	2.4	2.3-2.5	2.6	2.5-2.6	2.7	2.6-2.8
> 38	2.2	1.9-2.5	2.5	2.1-2.8	2.5	2.3-2.8	2.7	2.4-3.0
P[b]	.003		.002		.907		.870	

95% CI = 95% CI of the mean (lower bound and upper bound); CRT = capillary refill time; CRTp$_5$ = peripheral capillary refill time, application of pressure 5 s; CRTp$_{15}$ = peripheral capillary refill time, application of pressure 15 s; CRTs$_5$ = sternal capillary refill time, application of pressure 5 s; CRTs$_{15}$ = sternal capillary refill time, application of pressure 15 s.
[a]Determined by using the Mann-Whitney U test.
[b]Difference between groups as determined by using the Kruskal-Wallis test.

frequently used methods to measure CRT. These measurements were performed in a setting specifically designed to resemble daily practice at the ED and the ward, with two observers using identical methods under similar conditions. CRT measurements had slight to moderate agreement at best using a dichotomous outcome (normal vs prolonged) and moderate correlation using a continuous outcome (seconds).

TABLE 3] Agreement Between Two Investigators Assessed by Using the Intraclass Correlation Coefficient

Variable	Intraclass Correlation Coefficient	95% CI (Lower and Upper Bound)	Interpretation
CRTp$_5$	0.52	0.49-0.56	Moderate correlation
CRTp$_{15}$	0.54	0.50-0.57	Moderate correlation
CRTs$_5$	0.43	0.39-0.47	Low correlation
CRTs$_{15}$	0.46	0.42-0.49	Low correlation

All results, $P < .001$. See Table 2 legend for expansion of abbreviations.

TABLE 4] Agreement Between Two Investigators Assessed by Using κ Statistics

Variable	κ Statistic	95% CI (Lower and Upper Bound)	Interpretation
$CRTp_5$, upper range of normal 2 s	0.40	0.36-0.45	Fair agreement
$CRTs_5$, upper range of normal 2 s	0.30	0.26-0.35	Fair agreement
$CRTp_5$, upper range of normal based on age and sex	0.20	0.12-0.29	Slight agreement
$CRTs_5$, upper range of normal based on age and sex	0.13	0.04-0.22	Slight agreement
$CRTp_{15}$, upper range of normal of 4 s	0.32	0.24-0.41	Fair agreement
$CRTs_{15}$, upper range of normal of 4 s	0.23	0.15-0.31	Fair agreement
Subjective conclusion on CRT	0.44	0.37-0.51	Moderate agreement

All results, $P < .001$. See Table 2 legend for expansion of abbreviations.

To be of use in clinical practice, the interpretation of the results of CRT measurements should be easily reproducible. To date, there are only three studies in adults that report on interobserver agreement of CRT measurement at the distal phalanx after 5 s of pressure.[17-19] These studies show moderate agreement at best. In only one study was CRT measured without a timing device.[17] The other studies either showed a video with CRT[18] or used healthy volunteers in controlled circumstances, and CRT was determined with a chronometer or a video,[19] which does not reflect the worldwide use and interpretation of CRT in daily practice.[9]

To our knowledge, our study is the first to assess the optimal site and duration of pressure for CRT measurement in adults. As expected, our study found a correlation between the CRT measured at the distal phalanx and sternum. CRT measured at the distal phalanx was shorter than that measured at the sternum, as was found in children,[10] and we concluded that the phalanx and the sternum cannot be used interchangeably. The interobserver agreement on CRT was higher for the distal phalanx than for the sternum. A prolonged application of pressure (15 s), as used solely in the ICU, only resulted in a slightly higher interobserver correlation. Application of pressure for 5 s at the distal phalanx is easier to use, and most studies on CRT in the ED and the ward use 5 s application of pressure.[5,12] Therefore, based on these findings, we recommend uniform use of CRT and propose that CRT should only be measured at the distal phalanx with 5 s of pressure.

However, why measure CRT? CRT was introduced by Beecher in World War II to identify shock in battlefield survivors[24]; it is still used today to assess peripheral circulation and in early detection of shock.[2,6] Although our study showed a correlation between CRT and a

MAP < 65 mm Hg, we found no correlation between CRT and an abnormal pulse rate, which is an early indicator of shock. In the detection of shock in its early stages, the additional value of CRT seems limited, which is supported by previous research.[14,15] However, some studies show the predictive value of CRT on long- and short-term mortality. In a retrospective study in oncology patients, a prolonged CRT ($\geq$ 2 s) was predictive for both coronary care unit admission and 30-day mortality.[3] A prospective study in ED patients found that a prolonged CRT as a continuous variable was associated with an increased risk of mortality at 1 and 7 days.[4]

The present study also illustrated the power of FMR study design and its potential as a methodologic tool for clinical research. Compared with conventional studies, FMR has multiple similarities. In preparation of the study, FMR requires the same steps in designing and setting up (eg, protocol development, ethical board approval, instruction of collaborators). However, FMR exhibited many additional advantages. It facilitated inclusion of large numbers of patients from multiple centers (and the resulting data) within a short period of time. This inspiring and new research method, combined with an appealing research question, led to high participation of hospitals. The FMR approach also encouraged all the members of the medical team to participate in research. Most investigators in our study and almost one-half of the ambassadors were residents, who are often mainly focused on patient care and otherwise not regular participants of research. FMR engaged them in the process of research and exposed them to its various aspects. All these advantages come with limited time investment and low costs.

Our study has limitations. Given the cross-sectional nature of this study, no follow-up data were collected. Therefore, no associations with outcomes of disease,

including mortality, were examined. Data collection was performed by using standardized procedures after provision of standardized instructions; however, given the large number of centers and investigators, it is inevitable that small differences exist in the collection of data. Many of the collected variables are subjective and therefore open to interpretation, and they can be influenced by the clinical experience of the investigator. The application of pressure could differ between investigators, which could also affect CRT. In children, light pressure resulted in shorter CRT,[2] but in adults this effect has not been studied. We propagated counting, instead of using timing devices, to a resolution of one-half second, which could have led to lower agreement. Because the mean difference between all measurements was 0.1 s, the influence on our results was negligible while enabling us to compare various upper limits of normal. We believe that our study represents how CRT is used as a bedside test in daily practice worldwide, with all its shortcomings that hinder its users. In addition,

with 45% of the Dutch hospital organizations involved, our results are generalizable.

Conclusions

Based on the results of our study, especially the low interobserver agreement on a test that is difficult to standardize, combined with the currently available evidence, we concluded that the value of CRT in clinical practice is limited, and its routine use should be reconsidered. When CRT is used, it should be measured at the distal phalanx after applying pressure for 5 s. The practice of using the sternum for CRT measurement should be discarded.

In addition, the FMR method proved to be an inexpensive, quick, and reliable method to investigate "simple" clinical questions. FMR was used to recruit 1,734 participants in 1 day, and the majority of the data were ready for analysis within 24 h. We therefore believe this study exemplifies the power of FMR.

References

1. Schriger DL, Baraff L. Defining normal capillary refill: variation with age, sex, and temperature. *Ann Emerg Med*. 1988;17(9):932-935.

2. Pickard A, Karlen W, Ansermino JM. Capillary refill time: is it still a useful clinical sign? *Anesth Analg*. 2011;113(1):120-123.

3. Cooksley T, Kitlowski E, Haji-Michael P. Effectiveness of modified early warning score in predicting outcomes in oncology patients. *QJM*. 2012;105(11):1083-1088.

4. Mrgan M, Rytter D, Brabrand M. Capillary refill time is a predictor of short-term mortality for adult patients admitted to a medical department: an observational cohort study. *Emerg Med J*. 2014;31(12):954-958.

5. Lima A, Jansen TC, van Bommel J, Ince C, Bakker J. The prognostic value of the subjective assessment of peripheral perfusion in critically ill patients. *Crit Care Med*. 2009;37(3):934-938.

6. Lockey, Ballance J, Domanovits H, et al. *Advanced Life Support: ERC Guidelines 2010 Edition. 6th edition*. Edegem, Belgium: European Resuscitation Council; 2011.

7. Beecher HK, Simeone FA, et al. The internal state of the severely wounded man on entry to the most forward hospital. *Surgery*. 1947;22(4):672-711.

8. Champion HR, Sacco WJ, Carnazzo AJ, Copes W, Fouty WJ. Trauma score. *Crit Care Med*. 1981;9(9):672-676.

9. Lobos AT, Menon K. A multidisciplinary survey on capillary refill time: inconsistent performance and interpretation of a common clinical test. *Pediatr Crit Care Med*. 2008;9(4):386-391.

10. Crook J, Taylor RM. The agreement of fingertip and sternum capillary refill time in children. *Arch Dis Child*. 2013;98(4):265-268.

11. King D, Morton R, Bevan C. How to use capillary refill time. *Arch Dis Child Educ Pract Ed*. 2014;99(3):111-116.

12. van Genderen ME, Lima A, Akkerhuis M, Bakker J, van Bommel J. Persistent peripheral and microcirculatory perfusion alterations after out-of-hospital cardiac arrest are associated with poor survival. *Crit Care Med*. 2012;40(8):2287-2294.

13. Anderson B, Kelly AM, Kerr D, Clooney M, Jolley D. Impact of patient and environmental factors on capillary refill time in adults. *Am J Emerg Med*. 2008;26(1):62-65.

14. McGee S, Abernethy WB III, Simel DL. The rational clinical examination. Is this patient hypovolemic? *JAMA*. 1999;281(11):1022-1029.

15. Schriger DL, Baraff LJ. Capillary refill—is it a useful predictor of hypovolemic states. *Ann Emerg Med*. 1991;20(6):601-605.

16. Lewin J, Maconochie I. Capillary refill time in adults. *Emerg Med J*. 2008;25(6):325-326.

17. Anderson B, Kelly A, Kerr D, Jolley D. Capillary refill time in adults has poor inter-observer agreement. *Hong Kong J Emerg Med*. 2008;15:71-74.

18. Brabrand M, Hosbond S, Folkestad L. Capillary refill time: a study of interobserver reliability among nurses and nurse assistants. *Eur J Emerg Med*. 2011;18(1):46-49.

19. Espinoza ED, Welsh S, Dubin A. Lack of agreement between different observers and methods in the measurement of capillary refill time in healthy volunteers: an observational study. *Rev Bras Ter Intensiva*. 2014;26(3):269-276.

20. Semler MW, Stover DG, Copland AP, et al. Flash mob research: a single-day, multicenter, resident-directed study of respiratory rate. *Chest*. 2013;143(6):1740-1744.

21. Longman Dictionary of Contemporary English. http://www.ldoceonline.com/dictionary/flashmob. Accessed August 16, 2016.

22. Dellinger RP, Levy MM, Rhodes A, et al. Surviving Sepsis Campaign: international guidelines for management of severe sepsis and septic shock, 2012. *Intensive Care Med*. 2013;39(2):165-228.

23. Viera AJ, Garrett JM. Understanding interobserver agreement: the kappa statistic. *Fam Med*. 2005;37(5):360-363.

24. Beecher HK. The specialty of anesthesia and its application in the Harvard University-Massachusetts General Hospital Department. *Ann Surg*. 1947;126(4):486-499.