

Continuous Temperature Monitoring for Earlier Fever Detection in Neutropenic Patients: Comparison with Standard of Care

Neutropenic fever is a medical emergency in patients (pts) undergoing intensive chemotherapy or stem cell transplant (SCT). Early detection of fever allows for prompt infectious work up and initiation of broad spectrum antibiotics. A device that continuously monitors temperature can act as a clinical support tool to improve clinical outcomes and decrease incidents of sepsis and ICU transfer related to infection. In this study, we compare standard-of-care (SOC) intermittent temperature monitoring with a continuous temperature monitoring device on an inpatient stem cell transplant unit.

Consecutive pts who were admitted for high dose chemotherapy or SCT were asked to participate. The TempTraq temperature skin patch (TSP) (Blue Spark, Ohio), a FDA class II patch equipped with small temperature sensor, was utilized to monitor body temperature in real time. The patches were applied under the axilla every 24 hours. Data was received through an iPad or Smartphone remotely with the ability to set alerts. The TSP data was not utilized for clinical decision making. A questionnaire was designed to capture pts' experience. The correlation of temperature measurements by TSP and SOC was assessed by simple linear regression model. The temperatures detected by TSP between each SOC measurements (i.e., q4hrs) divided into four intervals based on the time lag from next SOC, 0-30 min(m), 30m-1hr, 1-2hr and 2-4hr and each interval counted as a separate binary, i.e., positive or negative based on presence of at least one value more than 100.2 F in a given interval. Receiver-operator characteristic (ROC) curves of the 4 time intervals were generated and area-under the curve (AUC) determined, assuming SOC as the gold standard test.

TSP data of 5,856 continuous hours were studied (i.e., on 17 pts, Table 1). The TSP data was successfully transmitted and displayed on the study iPad invariably. All pts were able to self-wear the patch through the hospital admission and the majority reported it was comfortable to wear and are interested in wearing it in future admissions or at discharge. (Table 2). The TSP in four intervals correlated significantly with SOC temperatures; 0-30m r: 0.29, $p < 0.001$, 30m-1hr r: 0.27, $p < 0.001$, 1-2hr r: 0.24, $p < 0.001$; 2-4 hr r: 0.21, $p < 0.001$ (Figure 1A). AUC of binary TSP in all four time intervals was significantly higher than SOC; 0-30 m AUC: 0.766 (CI: 0.708-0.824, $p < 0.001$); 30m-1hr AUC: 0.755 (CI: 0.701-0.809, $p < 0.001$); 1-2hr AUC: 0.718 (CI: 0.663-0.773, $p < 0.001$); 2-4 hr AUC: 0.702 (CI: 0.646-0.757, $p < 0.001$) (Figure 1B).

Taken together, our data suggest that remote and continuous skin temperature measurement is feasible in the inpatient setting and can provide the opportunity to detect fever earlier. Further studies to evaluate achievement of meaningful clinical outcomes with this device, as well as its utility in the outpatient setting, where self-reported fever can be less reliable, are warranted.

Table-1: Patients Characteristics

Age, median (range)	58 (29-78)
Gender (%)	
Male	11 (65)
Female	6 (35)
BMI>35	3 (18)
Diagnosis (%)	
Acute Myeloid Leukemia	7 (41)
Multiple Myeloma	4 (24)
Others	4 (24)
Reason for Hospital Admission (%)	
New Diagnosis Hem Malignancy	2 (12)
Relapsed Hem Malignancy	2 (12)
Refractory Hem Malignancy	1 (6)
Stem Cell Transplant	11 (65)
Length of Stay, median, range (days)	27 (4-77)
Time between hospital admit and fever, median, range (%)	10 (1-17)
Anti-viral Prophylaxis (%)	
Acyclovir	17 (100)
Anti-Bacterial Prophylaxis (%)	
Ciprofloxacin if Neutropenic before first fever	15 (88)
Amoxicillin/Clavulanic Acid	1 (6)
Levofloxacin	1 (6)
Antifungal Prophylaxis (%)	
Fluconazole	8 (47)
Voriconazole	5 (29)
Micafungin	4 (24)
Current Steroid Use	5 (29)
Culture Positive (%)	
Coag Negative Staph	2 (12)
ESBL Klebsiella	1 (6)
Corynebacterium	1 (6)
VRE Bacteremia	1 (6)
HHV 6 (Blood & CSF)	1 (6)
Source of Culture (%)	
Blood	5 (29)
CSF	1 (6)
Lung*	3 (18)
Parotiditis*	1 (6)
Bone Marrow Biopsy Site*	1 (6)
Intensive Care Transfer r/t Infection (%)	1 (6)
Sepsis	1 (6)
Septic Shock (%)	1 (6)

Presumed infectious source by imaging, not confirmed by biopsy * During past 3 Months

Table-2: Patient's questionnaire and answer distribution

Questionnaire and Answers	N* (%)
Did you wear the TSP every day in the hospital?	
○ Yes	15 (94)
○ No	1 (6)
○ I am not sure	0
If you did not wear the TSP every day, why did you stop wearing it?	
○ It was uncomfortable	0
○ It irritated my skin	0
○ I no longer wanted to participate in the trial	0
○ N/A – I wore the patch every day	15 (94)
○ Other	1 (6)
Did the TSP remain in place on your skin for 24 hours until it was time to be changed?	
○ Yes, it remained in place & it was only removed to be changed as instructed	13 (81)
○ No, it fell off my skin before it was time to be changed	3 (19)
Was the TSP easy to apply?	
○ Yes	16 (100)
○ No	0
○ I am not sure at this time	0
Was the TSP comfortable?	
○ Yes	15 (94)
○ No	1 (6)
○ I am not sure at this time	0
Did the TSP irritate your skin?	
○ Yes	1 (6)
○ No	15 (94)
○ I am not sure at this time	0
Are you interested in wearing the TSP for temperature monitoring in future hospital admissions or in the infusion center?	
○ Yes, I am very interested	9 (56)
○ No, I prefer traditional thermometer monitoring	1 (6)
○ I am not sure at this time	6 (37)
How would you rate your overall satisfaction with the TSP?	
○ Completely Satisfied	12 (75)
○ Partially Satisfied	2 (12)
○ Not Satisfied	0
○ I am not sure at this time	2 (12)

*The questionnaire was filled out by one non-English speaking patient, N=16

Figure-1. Diagnostic ability of TSP was assessed against SOC. The TSP between each SOC measurements (q4hrs) divided into four intervals, 0-30m, 30m-1hr, 1-2hr and 2-4hr. **A.** The detected temperature in four intervals correlated significantly with SOC temperatures. **B.** Receiver Operating Characteristic (ROC) curves of four time intervals. Each interval counted as a separated binary test. The lines represent prognostic sensitivity and false positive rates at increasing threshold values.



