

## Intelligent Medical Thermometer (Tympanic) for Accurate Measuring of the Body Temperature with the Ability of Alarming and Sending the Information through Cell-Phones

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Received: November 5 2013

Accepted: December 7 2013

### ABSTRACT

Controlling the patient's body temperature is one of the most essential responsibilities of a clinical nurses, which can be done through Rectum, Oral, axillary, and Tympanic. In this research it has been investigated a kind of a new digital intelligent thermometer (Tympanic), which can be easily installed in Patient's ear, and beside showing the body temperature, it has an important responsibility of letting the nurses know at a time when the body temperature of a face-to-face patient or afar away one through the domestic digital monitor or a hospital monitoring, in order to avoid any non-stopping damages of the temperature's increase meant. This product can be used whether at home or hospital.

**KEYWORDS:** temperature – thermometer – Alarming and announcing.

### INTRODUCTION

The increase meant in the body temperature more than the normal range (higher than 37°C), which can be controlled by setting system of anterior Hypothalamus, is called fever. [1] The normal Temperature of our body is around 37°C, equal to 98.6°F. The fever is a normal body reaction to most of the infections, but other factors also can cause the abnormal increase meant in the body temperature. [2] Around 25 – 30% of the doctor's annual visits and emergency cases are because of the fever [3,4]. The researches have proved that fever is the pediatrician's clinics to have the doctor's advices and taking care of their children. [5] In some references annual visiting because of the fever in children is 19-30% [6], and in some other references it's estimated around 50% [7]. Having a fever in body during the reaction leads to releasing the interior (pyrogen) factors such as: (infections – rheumatic – inflammation process and malignancy) exterior (pyrogen) factor's such as: (microbes – toxins [1] and other parts which sources are out of the body and is called exterior (pyrogen) These factors stimulate the microphage and as a result, proteins with molecule weights are produced. These Proteins are called interior (pyrogen). Interior (pyrogen), directly affects the receivers of Anterior Hypothalamus's nerve cells and as a result, prostaglandin is produced. These chemical arbitrates cause the changes in body temperature.

The temperatures in different parts of the body such as, axillary, rectum, Pulmonary artery, esophagus, pharynx, bladder, tympanic and so on, are different. [8,9] for instance the temperature of the rectum is 0.5°C higher than orals and the temperature of axillary is 0.5°C lower than oral's. Generally the temperature higher than 38°C in rectum after 3 min [10,11,12] and oral's temperature higher than 37.8°C after 2 min and axillary's 37.5°C after 5 min is known as a fever [13]. For measuring the fever using a rectal thermometer is more accurate than the other methods [14].

The normal temperature at a human body is measured by oral while relaxing is 0.4 ± 36.8°C. So each temperature measured by oral and is between 36.4 and 37.2°C is normal. Fever can increase the patient's immunity response against the infections; therefore, it can be beneficial [2, 11, 15].

In hospitals a clinics controlling the patient's body temperature as one of the nurse's responsibilities, is a necessity for a better taking care of the patient [16]. Each body temperature's measuring method has its own advantages and disadvantages; therefore, in selecting a method or place of measuring we should be wise to choose a method in which first, it doesn't reflex the central temperature. Second, it should have a high measuring rate. It should be hygienic non-invasive, economic and acceptable for each patient [8, 16] so existing of different methods and their advantages and disadvantages has its own challenges in clinical taking care of the patients. In methods such as: axillary, under the tongue, rectum, pulmonary artery, esophagus, pharynx, bladder, Tympanic and so on, the temperature of the pulmonary artery is known as the golden standard central body temperature. [8, 17] Some Researches have reported that the tympanic's temperature is the best index of the central temperature and can be ... easily with the least damaging, through the local place. [18, 19, 20] It's assumed that the blood circulation of the tympanic's membrane and body temperature controlling center of Hypothalamus, are both provided by carotid artery; therefore, measuring the temperature of the tympanic's

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membrane in dictates the central body temperature [21, 22]. Also Dzarra and colleagues(2009), after comparison at tympanic's temperature with rectals and axillary's with under tongues reported that Tympanic's temperature in compassion to the others is more closed to rectum's [23].

For measuring the temperature in medicine, different thermometers are used. Previously, most doctors measured the temperature by glass or mercuric temperatures. Since using mercuric in temperatures can be harmful and can bring undesirable results for the environment and the health, now's a day, glass temperatures are no more used for measuring. Interestingly, U.S.A pediatrician's academy has forbidden using the mercuric temperatures for kinds. These days different kinds of temperature are replaced with the mercuric ones and also, the usages of the new temperatures are easier and you can see the result in a very short time. The first real product for measuring the temperature was used and invented by Galilean 1592, which didn't used any specific measurement method. But in 1635, a person who was called Ferdinand Touscon created a new thermometer in which Alcohol was used for measuring. Since Alcohol evaporates gradually, those thermometer wasn't useful after a while. Finally, in 1640, an Italian scientist, Create a new model at thermometer which is new known as the glass thermometers and instead at Alcohol they worked with mercuric. since reading the fever's temperature in mercuric thermometer was not easy, after the invention of the infrared ray thermometer in 1991, a new region of thermometer were designed and produced, which were more accurate and easily it could measure the body temperature, had an infrared sensors that could measure the body temperature by the energy which is broadcasted by ear to Tympanic. And since the tympanic is inside our body, it could act as an accurate sensor and it could measure the body temperature in less than 2 min. Most digital thermometer, beeps after measuring and the result is monitored on the top. Generally in comparison to glass thermometer, the digital ones are faster and more accurate.

These days different kinds of thermometers can be found in markets, in this research we are trying to investigate and produce a new kind of a digital intelligent thermometer (tympanic), and with assuming the advantages and advantages of this measuring system, it has been tried to present a more accurate mechanism and method, with more equipment's for medical uses, while accurately measuring the temperate, it can announce the nurses when the incensement in temperature occurs.

## MATERIALS AND PROCEDURES

We investigate the clinical thermometers that com measure the temperature from  $-40$  up to  $+100^{\circ}\text{C}$  and the normal range of  $35$  to  $41^{\circ}\text{C}$ . Electronic thermometers include probe and digital monitor or analogue quantifier. Probe and quantifier are connected to a gate by cable. The thermocouple sensor or thermistor, in each probe causes the production of electrical signals, which are different with each other according to their temperatures and changes. These signals transfer to the monitor.

Thermistors include a heavy oxidized metal (usually from mg.ni.cu. iron. and zinc). Special resistance of the thermistor and semiconductors used for biomedical applications is between  $0.1$  and  $100\ \Omega\text{m}$ . The mentioned resistance decreases with the incensement of the temperature and vice versa. By leading the electricity to this resistance and reaching to the voltage at the both sides we can find the changes of the temperature. Thermistors can respond very quickly and they're cheap and small. (It com be built smaller than  $0.5\ \text{mm}$ .)They have a very high Sensitiveness to the temperature's changes. ( $-3, -5^{\circ}\text{C}$ ) and desirable long lasting feature. ( $\pm 0.2\%$  of the appearance resistance) and are sensitive to the changes in temperature. For measuring the oral's temperature before stability, the period of changing the probe's temperature decreases to  $0.1^{\circ}\text{C/s}$ , and a fix number, around  $1^{\circ}\text{C}$  is added to this number too. The thermocouple's sensor is made up of 2 different metals one of which is usually Cu. and the other one is Constantine. (Ni and Cu) are fixed to gather in two sections. In a time when the two metal's connections have different temperature, a proper voltage is appeared which is related to this difference. Inelectronical thermometer one of the metal's connections is stable in a fixed temperature(Central connection) .while the second connection snows the body temperature according to the probe's temperature. (Measuring connection).This procedure causes production of a proper voltage related to the temperature. According to different probes and circuits, the responding time for different system is various. The top of the probe which is usually coder produces the first and leading temperature and as a result of comparing it with the body temperature, according to the system's application, it sends a signal to the monitoring system. Steady – state sends the final out-going mode space after the comparison and modification. The predictive model, measures the first temperature according to some special diagrams. This model is more stable on the other hand it's less accurate. While in the predictive model the arrangement and rapidity is very important, as the first temperature has a vital role in the application and the monitoring of this kind of system. Most systems have both application mode and can be switched manually. Related to the differences bib probe's sizes, just one is acceptable and more comfortable for the patients, although using some of them is more comfort table and easier them the others. Most of the probes used on the body; some plate which are dipped to a sticky foams are used. Most thermometers have some electronical features such as: alarming – monitoring the final temperature and a switch for choosing the temperature model according to  $0^{\circ}\text{C}$  for  $0^{\circ}\text{F}$  while most of them have the ability to set an

automatic calibration. According to the application, different notifications can be monitored, such as: Low battery- uncalibrated probe damaged-body temperature-heart's pulse- no connection and blood pressure. [24-25]

In this kind of thermometer which is called non-contact, the temperature's measuring is applied through the Infrared energy radiated from ear. This method is healthy, hygienic and quick. This research was a comparison one which was applied in one of the local hospital. The cases were 107 men and 299 women selected from internal medicine (29/8%) – emergency (13/4%) b- operation section (14/3%) gynecology (14/2%) – pediatrician (11%) and clinic (17/3%).

The digital thermometer model Rossmax TB100-TB500 , which measured through (oral-anal-axillary-forehead) and is intelligent (tympanic), was examined after the patient's wise agreement For reassurance of the stability at the thermometer, calibration method was used; therefore, examination was repeated in fixed periodical time for an exact results, and during the procedure the result were examined many times. Although, according to its company's report, this model (Rossmax TB100-TB500) and medical thermometer have an interior error at 0.1°C and it shows the same accuracy of these two thermometers.

Whilemeasuring the tympanic's temperature in tympanic method, the patient's ear is softly pulled out and back so that the tympanum can be in a straight line and the tympanic's membrane can be viewed by the sensors. After enabling the thermometer (tympanic), the temperature is monitor and saved also it can alarm, send message or call to the doctor's and nurse's cell phone.

In this research as an aid in analyzing, five assumptions were used. First, in oral method the normal degree is 37°C, 98/6°F within 1 min. Second, in axillary method the normal degree is 36/5°C, 97/7°F within 1 min. Third, in anal method this degree is 37/6°C, 99/7°F within 1 min. Forth, in forehead method the normal degree is 34°C-42/2°C, 93/2°F-108°F within 30 min. And finally, in tympanic method this degree is 37/0°C, 98/6°F in less lath 2 seconds.

**RESULTS**

Data analysis indicated that 31/8% of the cases were male and 68/2% were female. Cases were from 6-65 (20/07 + 43/52) years old. They were selected from different section at hospital. 29/8% from internal section, 13/4% from emergency, 14/2% from gynecology, 11% from Pediatrics and 17/3% from clinics. The measuring was done by the researchers team at 8 a.m. and they used thermometer model Ross max TB100-TB500 (oral – anal- axillary – forehead), with the ability of alarming, sending message and calling, and tympanic method specially for measuring the changes in patients body temperature.

- \* Digital intelligent thermometer's accuracy: (oral – anal- axillary):  
±0/1°C, 35/5°C – 42/0°F (±0/2°F -95/9°F-107/6°F)  
±0/2°C less than 35/5°C or more than 42/0°F (±0/4°F less than 95/9°F or more than 107/6°F)  
In normal standard degree 25°C, 77°F
- \* Application breadth of the oral – anal- axillary thermometer:  
32/0°C up to 42/9°C (90°F up to 109/9°F)
- \* Forehead thermometer's accuracy:  
± 0/3°C (0/5°F) in 34 up to 42/2°C(93/2°F up to 108°F)
- \* Application breadth of forehead thermometer:  
15 up to 40°C (59°F up to 104°F)
- \* Tympanic digital thermometer's accuracy:  
(± 0/2°C, 35/5°C up to 42/0°C)  
(± 0/2°F, 95/9 up to 107/6°F)
- \* Application breadth at Tympanic digital thermometers:  
32°C up to 42/9°C  
90°F up to 109/9°F)
- \* Error rate of Tympanic digital thermometer:  
0/1 in 35/5°C up to 42/2°C  
(95/9°F up to 107/96°F)

**Table1:** The results obtained from the performed researches on the hospital

H	G	F	E	D	C	B	A	X
80-85%	95-100%	80-85%	100%	80-85%	98-100%	85-90%	100%	A'
75-80%	95-100%	75-80%	100%	85-90%	99-100%	85-90%	100%	B'
80-85%	95-100%	70-75%	100%	85-90%	98-100%	86-91%	100%	C'
75-80%	95-100%	80-85%	100%	80-85%	99-100%	86-91%	100%	D'
80-85%	95-100%	70-75%	100%	80-85%	99-100%	85-90%	100%	E'
80-85%	95-100%	75-80%	100%	85-90%	99-100%	86-91%	100%	F'

A: Tympanic digital thermometers, economizing the personnel's time.

B: anal-axillarythermometer, economizing the personnel's time.

C: Decreasing the nurse's undesirable Error rate, Tympanic digital thermometer.  
D: Decreasing the nurse's undesirable Error rate, oral- anal- axillary thermometer.  
E: nurse's satisfaction rate, tympanic digital thermometer.  
F: nurse's on time taking care at the patients, digital Tympanic thermometer.  
H: Nurse's on time taking care of the patients, oral-anal-axillary thermometer.

X: Hospital's section

A': internal section/ B': emergency section/ C': operation section/ D': gynecology section/

E': pediatrics section/ F': clinic

## CONCLUSION

Since default controlling at the enhancement in the body temperature can use irremediable damages in human, especially in Kids, this production can monitor the body temperature in face-to-face ones through domestic or hospital monitoring, also through cell phone specially in the nurse's absence, unpurpose Error at the time of nurse's relating time the night, this production can announce by alarming whenever the body temperature is increasing in order to control it before any damages happens.

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