April 2010

Range for Normal Body Temperature in Hemodialysis Patients and Its Comparison with That of Healthy Individuals

Rabia Hasan
Aga Khan University

Mehreen Adhi
Aga Khan University

Syed Faisal Mahmood
Aga Khan University

Fatima Noman

Safia Awan
Aga Khan University

See next page for additional authors

Authors
Rabia Hasan, Mehreen Adhi, Syed Faisal Mahmood, Fatima Noman, Safia Awan, Fazal Akhtar, Anwar Naqvi, and Adeeb ul Hassan Rizvi

Original Paper

nephron Clinical Practice

Nephron Clin Pract 2010;114:c303–c308
DOI: 10.1159/000276583

Received: November 29, 2008
Accepted: May 14, 2009
Published online: January 20, 2010

Range for Normal Body Temperature in Hemodialysis Patients and Its Comparison with That of Healthy Individuals

Rabia Hasan[a] Mehreen Adhi[a] Syed Faisal Mahmood[a] Fatima Noman[c]
Safia Awan[a] Fazal Akhtar[b] Anwar Naqvi[b] Adeeb ul Hassan Rizvi[b]

[a]Aga Khan University Hospital, [b]Sindh Institute of Urology and Transplantation, [c]Liaquat National Hospital, Karachi, Pakistan

Key Words
Fever · Hemodialysis · Thermoregulation · Chronic kidney disease

Abstract
Background/Aims: Patients with chronic kidney disease undergoing hemodialysis have an altered homeostasis leading to altered body temperatures. We aimed to determine the range for normal body temperature in hemodialysis patients and compared it to healthy individuals. Also, we determined how much axillary temperatures differed from oral temperatures in both groups and whether axillary temperature is affected by the presence of an arteriovenous fistula (AVF) in hemodialysis patients. ***Methods:*** Oral and axillary (left & right) temperatures were recorded using an ordinary mercury-in-glass thermometer in 400 subjects (200 hemodialysis patients, 200 healthy individuals) at the Sindh Institute of Urology and Transplantation from mid-May to mid-June 2006. Comparisons were made between the temperatures of both groups. ***Results:*** Mean oral temperature in hemodialysis patients was higher than in healthy individuals [98.7°F (37°C) vs. 98.4°F (36.8°C); $p < 0.001$], as was the mean average axillary temperature [97.7°F (36.5°C) vs. 97.5°F (36.3°C); $p = 0.02$] and mean left axillary temperature [97.9°F (36.6°C) vs. 97.6°F (36.4°C); $p < 0.001$]. The fistula arm had higher axillary temperature in 77 (44%) hemodialysis patients. The difference between oral and axillary temperatures varied widely, making it impossible to obtain an accurate correction factor in both groups. ***Conclusion:*** Hemodialysis patients have higher normal body temperatures than healthy individuals. Axillary temperatures require cautious interpretation. In hemodialysis patients, the non-fistula arm should be preferred for recording axillary temperatures, as the presence of AVF may cause discrepancies in temperature measurements.

Introduction

Despite the widespread application of thermometry in clinical medicine, the definition of normal body temperature is still under debate [1]. Normal body temperature has traditionally been considered as 98.6°F (37°C) [2]. However, a recent study indicates that normal body temperature (measured orally) not only varies amongst individuals, but also throughout the day, and can range from 96°F (35.5°C) in the morning to 99.9°F (37.7°C) in the evening, with an overall average of 98.2°F (36.7°C) [2].

KARGER

Fax +41 61 306 12 34
E-Mail karger@karger.ch
www.karger.com

1660–2110/10/1144–0303$26.00/0

Accessible online at:
www.karger.com/nec

Dr. Syed Faisal Mahmood
Faculty of Health Sciences, Medical College, The Aga Khan University Hospital
Stadium Road, PO Box 3500, 74800 Karachi (Pakistan)
Tel. +92 21 493 0051, ext. 4574/4655, Fax +92 21 493 4294 or +92 21 493 2095
E-Mail faisal.mahmood@aku.edu

There are many factors causing this variation in normal body temperature, such as age [3, 4] and gender [5, 6]. The body temperature is also very sensitive to hormone levels and women exhibit an increase in body temperature of about 0.9°F at the time of ovulation [7]. In addition, exercise, digestion and underlying disorders, e.g., shock and neuro-psychiatric disorders such as chronic depression, may also alter the thermoregulatory response [7]. Ambient temperature and humidity have also been shown experimentally to affect body temperature [8].

Patients with chronic kidney disease (CKD) undergoing renal replacement therapy in the form of hemodialysis have an increased chance of infection, the risk of which is increased by immunosuppression associated with uremia, vascular access-related infections and constant nosocomial exposures [9]. Thus, an early diagnosis of infection is imperative in this population. Unfortunately, CKD itself as well as hemodialysis may also affect the body temperature. Patients undergoing hemodialysis have an altered homeostasis, which may lead to an altered body temperature, i.e., resulting in a body temperature which is higher or lower than a normal individual [10–14]. Additionally, the long-term survival and quality of life of patients on hemodialysis is dependent on an appropriately placed vascular access; the most reliable long-term method of achieving this being the construction of an arteriovenous fistula (AVF) [15, 16]. The resultant arterialization of the vein alters the blood flow distal to the AVF and can theoretically change the skin and axillary temperature [17].

There is limited information regarding the normal body temperature in hemodialysis patients, how this compares with the healthy population and the effect of the AVF on the reliability of measuring body temperature. We therefore carried out a study to determine the range for normal body temperature in hemodialysis patients and compared this to body temperatures in healthy individuals. We also compared how much the axillary temperature differs from the oral temperature in both the groups and whether there is any effect of the fistula site on the axillary temperature in hemodialysis patients.

Materials and Methods

We carried out an observational cross-sectional study at the Sindh Institute of Urology and Transplantation (SIUT). Two groups of subjects were enrolled; the first was comprised of patients undergoing hemodialysis, and the second was a comparator group consisting of healthy individuals (subjects accompanying patients to the various clinics at the SIUT). In both groups, subjects were enrolled between mid-May and mid-June 2006. Only adults (subjects ≥18 years) were included in the study. Additionally, in the hemodialysis patients group, we only enrolled patients who were receiving dialysis through a functional fistula for >6 months.

A screening questionnaire was administered in each case, which contained details about the age, sex, ambient temperature, time of the day, pregnancy and last menstrual period (LMP) in the case of females, history of any chronic medical illnesses, e.g., diabetes and hypertension, history of any recent infections, history of fever associated with hemodialysis and fistula site. Subjects having any recent infections and history of fever associated with hemodialysis (both confirmed on the basis of detailed history and past medical records) and those with any chronic medical illnesses (other than CKD) were excluded to avoid discrepancies in temperature recordings. Similarly, pregnant women and women suspected to be at or around their ovulation (based on the LMP) were also excluded. Additionally, in the hemodialysis patients group, patients undergoing hemodialysis through a central line and those with flow-related fistula complications were excluded. The mean ages of the healthy individuals and the hemodialysis patients were used to devise a cutoff in order to divide each of the categories of subjects into a younger and an older age.

Each subject's body temperature was recorded using an ordinary mercury-in-glass thermometer. A total of 5 similar thermometers from the most widely used brand were used throughout the study. For hemodialysis patients, the temperature recordings were made in the waiting area of the hemodialysis center before the patients underwent hemodialysis, and for healthy individuals, the temperature recordings were made in the waiting areas of various clinics. The temperature of each subject was first taken orally by positioning the bulb of the thermometer in the sublingual pocket. For axillary temperature measurements, the bulb of the thermometer was placed midway between the anterior and posterior axillary folds, first in the right, and then in the left axilla, and the temperature recordings for each axilla were recorded. For each temperature measurement the thermometer was kept at the body site for 2 min. Only 2 individuals were involved in recording oral and axillary temperatures of all the subjects, and each temperature recording was rechecked by both individuals so as to minimize the visual error in reading the temperature. An average axillary temperature was calculated using the mean of right and left axillary temperature for each subject in both groups. A difference of more than 1°F between the oral and average axillary temperatures was defined as a discrepancy.

The thermometer bulb was wiped with 70% alcohol at room temperature before checking the temperatures at different sites. All temperature recordings were made during the day time. The ambient temperature of each waiting area was measured by using a wall-mounted thermometer with a measuring range between –20°F (–28.8°C) and 140°F (60°C). This thermometer was mounted at a central point in the waiting areas each day and the ambient temperature was recorded before each subject's body temperature recording was made. The mean of the ambient temperatures to which the subjects were exposed in both groups were used as a cutoff to divide the subjects into high and low ambient temperature categories in both groups.

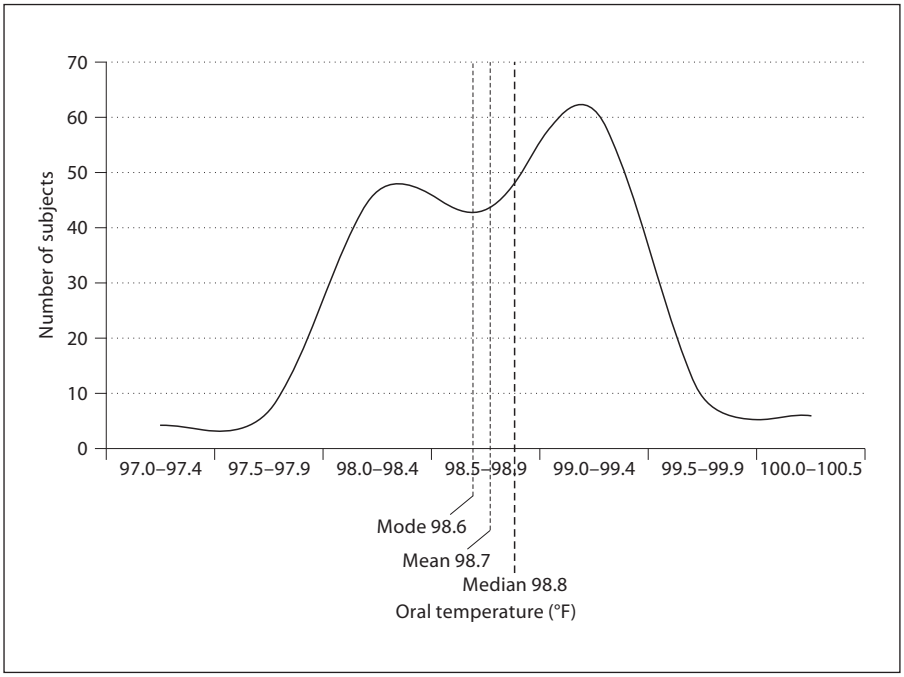

Fig. 1. Normal distribution curve for oral temperatures in hemodialysis patients. Graphical representation of the distribution of oral temperatures in hemodialysis patients in the study population, depicting the mean oral temperature, median and mode. The normal oral temperature in hemodialysis patients ranged from 97.2°F (36.2°C) to 100.4°F (38°C).

As there is no formal ethical committee in SIUT, permission and approval of the work was taken from the Director of the Institute. Informed consent of each subject was taken and confidentiality and anonymity of the record was maintained.

All analyses were conducted by using the Statistical Package for Social Science; SPSS (Release 16.0, standard version, SPSS© 1989–2002). A descriptive analysis was done as mean ± standard deviation for quantitative variables and number (percentage) for qualitative variables. Differences in proportions were assessed by using the χ^2 test or Fisher exact test where appropriate. All p values were 2-sided and considered as statistically significant if <0.05.

Results

A total of 400 subjects were evaluated, which included 200 subjects in the hemodialysis patients group and 200 subjects in the healthy individuals group, comprising equal numbers of males and females in each group.

In the hemodialysis patients group, 23 subjects were excluded due to history of fever associated with hemodialysis. Of the remaining 177 hemodialysis patients, the mean age of the subjects was 30 ± 10.6 years and 91 (51.4%) of the subjects were males while 86 (48.5%) were females. The ambient temperature of the waiting area of hemodialysis ranged between 76°F (24.4°C) and 79°F (26.1°C) [mean ± SD = 77.1°F (25°C) ± 0.96°F].

In the healthy individuals group, 16 subjects were excluded due to history of recent infections (urinary tract infections, respiratory infections and sore throat). Of the remaining 184 healthy individuals, the mean age of the subjects was 34 ± 10.6 years and 97 (52.7%) of the subjects were females, while 87 (47.2%) were males. The ambient temperature of the waiting areas of the various clinics ranged between 79°F (26.1°C) and 90°F (32.2°C) [mean ± SD = 82.9°F (28.2°C) ± 1.90°F].

The range for normal oral temperature in the hemodialysis patients group was between 97.2°F (36.2°C) and 100.4°F (38°C); mean ± SD: 98.7°F (37°C) ± 0.59°F (fig. 1), while that of the healthy individuals group was between 97°F (36.1°C) and 99.8°F (37.6°C); mean ± SD: 98.4°F (36.8°C) ± 0.52°F. The mean oral temperature in the hemodialysis patients group was significantly higher than that of the healthy individuals group; [98.7°F (37°C) vs. 98.4°F (36.8°C); $p < 0.001$]. The variation in oral temperature in the hemodialysis patients group was also greater than in the healthy individuals group (fig. 2).

There were no significant age- and ambient temperature-related variations in body temperature in either group. Nor were there any sex-related variations in the body temperature in the hemodialysis patients group, but interestingly, a significant sex-related variation was found in the body temperature of males and females [mean

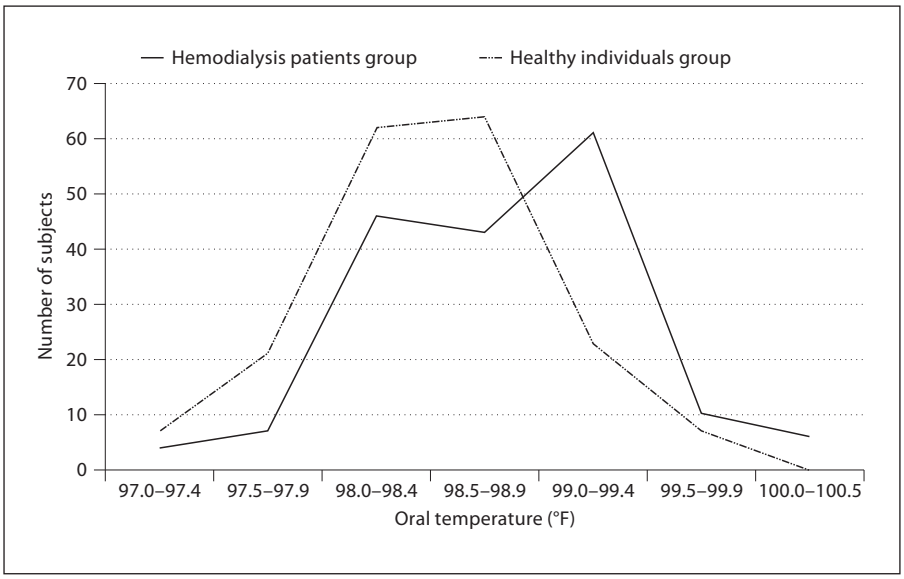

Fig. 2. Variation of normal oral temperatures in hemodialysis patients and healthy individuals. Graphical representation of the variation in the normal oral temperatures in hemodialysis patients group and the healthy individuals group show a wider variation of normal body temperature in hemodialysis patients when compared to healthy individuals.

Table 1. Age-, sex- and ambient temperature-related variations in normal body temperature in hemodialysis patients and healthy individuals

	Hemodialysis patients group						Healthy individuals group					
	age, years		sex		ambient temperature °F/°C		age, years		sex		ambient temperature °F/°C	
	<30 (n = 107)	≥30 (n = 70)	male (n = 91)	female (n = 86)	<77.1/25 (n = 47)	≥77.1/25 (n = 130)	<34 (n = 92)	≥34 (n = 92)	male (n = 87)	female (n = 97)	<82.5/28 (n = 21)	≥82.5/28 (n = 163)
Mean temperature °F/°C	98.8/37.1	98.7/37	98.7/37	98.7/37	98.9/37.1	98.7/37	98.5/36.9	98.4/36.8	98.3/36.8	98.5/36.9	98.5/36.9	98.4/36.8
p value	0.35		0.59		0.20		0.68		0.01		0.51	

98.5°F (36.9°C) vs. 98.3°F (36.8°C); p = 0.01] in the healthy individuals group (table 1).

In the hemodialysis patients group, the axillary temperature in the right axilla ranged from 95°F (35°C) to 100.4°F (38°C) [mean ± SD = 97.6°F (36.4°C) ± 0.92°F] and that in the left axilla ranged from 95.2°F (35.1°C) to 100.4°F (38°C) [mean ± SD = 97.9°F (36.6°C) ± 0.81°F]. Most of the hemodialysis patients (88.6%) had a fistula in the left arm while 11.4% had a fistula in the right arm. The arm with the fistula had a higher temperature in 77 (44%) of the hemodialysis patients. In the healthy individuals group, the axillary temperature in the right axilla ranged from 96°F (35.5°C) to 99.6°F (37.5°C) [mean ± SD = 97.5°F (36.3°C) ± 0.72°F] and that in the left axilla ranged from 96°F (35.5°C) to 99.4°F (37.4°C) [mean ± SD = 97.6°F (36.4°C) ± 0.74°F]. There was no significant difference in the mean right axillary temperature in the hemodialysis patients and healthy individuals, but as expected, the mean left axillary temperature in the hemodialysis patients group was significantly higher than that of the healthy individuals group [97.9°F (36.6°C) vs. 97.6°F (36.4°C); $p < 0.001$].

The average axillary temperature ranged from 95.1°F (35°C) to 100.4°F (38°C) [mean ± SD = 97.7°F (36.5°C) ± 0.78°F] in hemodialysis patients, while it ranged from 96.1°F (35.6°C) to 99.5°F (37.5°C) [mean ± SD = 97.5°F (36.3°C) ± 0.68°F] in the healthy individuals. The average axillary temperature in hemodialysis pa-

tients was therefore significantly higher than that of healthy individuals [97.7°F (36.5°C) vs. 97.5°F (36.3°C); p = 0.02]. The variation in the average axillary temperatures in hemodialysis patients group was also greater than in the healthy individuals group.

A discrepancy in the oral and the average axillary temperature was found in 84.7% of the patients in the hemodialysis patients group and 36.4% of the subjects in the healthy individuals group. As there was a wide variation in the difference between oral and average axillary temperatures, an accurate oral equivalent of axillary temperature could not be obtained in either group.

Discussion

The primary objective of this study was to demonstrate if any thermal imbalance exists in patients between dialysis treatments. The higher body temperature in patients undergoing hemodialysis when compared with the healthy individuals indicates that patients undergoing hemodialysis may have some degree of disequilibrium in their homeostasis. The cause of this increase in core temperature is still under debate [10]. The increase in body temperature may be due to a chronic inflammatory process in these patients, which may be depicted if further studies are carried out to measure the cytokine levels in these patients. It has also been suggested that peripheral vasoconstriction as a result of hypovolemia leads to reduced dissipation of heat from the skin, which may be the main cause of this increase [10]. Apart from reduced heat loss, an increased metabolic rate during dialysis might lead to heat accumulation [11]. However, there are other studies pointing towards a subnormal body temperature in hemodialysis patients [12–14]. The explanation for subnormal body temperature in hemodialysis patients remains speculative and it has been hypothesized that the degree of uremia may be related to the hypothermia [12].

Many factors can contribute to the variation of body temperatures. Studies have reported age-, sex- and ambient temperature-related variations in normal body temperature in healthy individuals [3–7]. In our study, there was no effect of age on the body temperature in both groups. As most of our subjects were in a cool and covered area of the hospital, variations in the ambient temperature were minimal, and this may have been the reason for the minimal effect of ambient temperature on the body temperature of both groups. While the healthy women had a higher temperature compared to the men, this was not demonstrated in the hemodialysis group, possibly due to the small sample size.

Avitsian et al. [16] recently reported that an upper extremity AVF alters blood pressure and temperature measurements when compared with the contralateral non-AVF side. Our study also showed an increase in the axillary temperature of the arm with the AVF in approximately half the hemodialysis patients. Most of the hemodialysis patients in our study had an AVF in their left arm, and the significant difference that was found between the left axillary temperatures of hemodialysis patients and healthy individuals may have been reflective of this. The increased temperatures are likely due to an increase in the blood flow through the fistula. Thus, the fistula site should be an important consideration when recording axillary temperature, as the arm with the fistula is unlikely to provide the correct estimate of axillary temperature.

Loudon showed that axillary temperature measurements with mercury thermometers vary from 2.6°F lower to 1°F higher than simultaneous oral measurements [18]. Nichols et al. [19] reported that axillary temperatures exhibit differences of 0°F to 4.2°F compared with oral temperature readings in adults. Our study was consistent with a wide variation in the difference between oral and average axillary temperatures, and the common practice of adding 1°F to the axillary temperature could not accurately predict the oral temperature in either hemodialysis patients or the healthy individuals.

The correct estimate of body temperature is important clinically for the early diagnosis and consequent treatment of infections. In CKD patients undergoing hemodialysis, this is particularly imperative, as these patients are prone to developing infections due to immunosuppression and nosocomial exposure. On the other hand, discrepancies in temperature recordings and false interpretation of a higher body temperature as fever, may lead to irrational use of antibiotics and as a consequence, development of resistant organisms.

Limitations of our study included the fact that the thermometer was not calibrated between subjects, and that the thermometer was not placed at the body site for longer than 2 minutes. However, we opted for a shorter measurement time in order to simulate real-life conditions. The correct placement of the thermometer at the body site and the possible visual error in reading the temperature recordings were other limitations pertaining to the use of an ordinary mercury-in-glass thermometer. However, only 2 individuals were involved in the temperature recordings and all the temperature recordings

were rechecked by both individuals so as to minimize the visual error, and a conscious effort was made to place the thermometer correctly, especially in the axillae.

Conclusion

Patients with CKD undergoing hemodialysis have higher normal body temperatures than healthy individuals. There is a wide variation in the difference between oral and axillary temperature measurements, thus making it impossible to obtain an accurate correction factor. Therefore, axillary temperatures should be interpreted with great caution. Also, since the axillary temperature of hemodialysis patients is affected by the presence of an AVF, when taking axillary temperature in hemodialysis patients, the fistula site should be taken into consideration, and the non-fistula arm should be preferred for axillary temperature recordings, so as to avoid discrepancies in temperature measurements.

References

1 Cohen J, Powderly WG: Infectious Diseases, ed 2. St. Louis, Mosby, 2004.
2 Sherwood L: Human Physiology from Cells to Systems. ed 5. New Delhi, Brooks/Cole-Thomson Learning, 2004.
3 Gomolin IH, Aung MM, Wolf-Klein G, Auerbach C: Older is colder: temperature range and variation in older people. J Am Geriatr Soc 2005;53:2170–2172.
4 Roy S, Powell K, Gerson LW: Temporal artery temperature measurements in healthy infants, children, and adolescents. Clin Pediatr (Phila) 2003;42:433–437.
5 Mackowiak PA, Wasserman SS, Levine MM: A critical appraisal of 98.6 degrees F, the upper limit of the normal body temperature, and other legacies of Carl Reinhold August Wunderlich. JAMA 1992;268:1578–1580.
6 Sund-Levander M, Forsberg C, Wahren LK: Normal oral, rectal, tympanic and axillary body temperature in adult men and women: a systematic literature review. Scand J Caring Sci 2002;16:122–128.
7 Mackowiak PA: Temperature regulation and pathogenesis of fever; in: Mandell GL, Bennett's JE, Dolin R (eds): Douglas and Bennett's Principles and Practice of Infectious Diseases. ed 6. Philadelphia, Elsevier Churchill Livingstone, 2005, pp 703–717.
8 Zehner WJ, Terndrup TE: The impact of moderate ambient temperature variance on the relationship between oral, rectal, and tympanic membrane temperatures. Clin Pediatr (Phila) 1991;30:61–64.
9 Yazici H, Sever MS: Fever of unknown origin in a hemodialysis patient with a failed allograft. Hemodial Int 2007;11:296–299.
10 Van der Sande FM, Rosales LM, Brener Z, Kooman JP, Kuhlmann M, Handelman G, Greenwood RN, Carter M, Schneditz D, Leunissen KM, Levin NW: Effect of ultrafiltration on thermal variables, skin temperature, skin blood flow, and energy expenditure during ultrapure hemodialysis. J Am Soc Nephrol 2005;16:1824–1831.
11 Ikizler TA, Wingard RL, Sun M, Harvall J, Parker RA, Hakim RM: Increased energy expenditure in haemodialysis patients. J Am Soc Nephrol 1996;7:2646–2653.
12 Fine A, Penner B: The protective effect of cool dialysate is dependent on patients' predialysis temperature. Am J Kidney Dis 1996; 28:262–265.
13 Krämer M, Polaschegg, HD: The relevance of thermal effects during hemodialysis; in Friedman EA, Beyer MM (eds): American Society for Artificial Internal Organs, 39th Annual Meeting. M84. Philadelphia, J.B. Lippincott, 1993.
14 Rosales LM, Schneditz D, Morris AT, Rahmati S, Levin NW: Isothermic hemodialysis and ultrafiltration. Am J Kidney Dis 2000; 36:353–361.
15 Malovrh M: Vascular access for hemodialysis: arteriovenous fistula. Ther Apher Dial 2005;9:214–217.
16 Kumar P, Clark M: Kumar and Clark Clinical Medicine, ed 6. Edinburgh, Elsevier Saunders, 2005.
17 Avitsian R, Abdelmalak B, Saad S, Xu M, O'Hara J Jr: Upper extremity arteriovenous fistula does not affect pulse oximetry readings. Nephrology (Carlton). 2006;11:410–412.
18 Loudon ISL: On taking the temperature in the mouth and axilla. Lancet 1957;268:233–235.
19 Nichols GA, Kulvi RL, Life HR, et al: Measuring oral and rectal temperatures of febrile children. Nurs Res 1972;21:261–264.