Air-Fluidized Therapy

Physical Properties and Clinical Uses

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Abstract: Since the late 1960s, air-fluidized therapy (AFT) has been effectively used to treat patients with pressure ulcers, burns, and many other clinical problems. Much of the demonstrated efficacy is believed to be associated with the unique fluid environment provided by AFT that is fundamentally different from the support provided by surfaces made up of conventional solid materials. Fluid support maximizes the envelopment of the body while significantly reducing shear, friction, and pressure, and mechanical stress applied to the skin and subcutaneous tissue. Additionally, the variable temperature airflow allows the microclimate to be controlled according to needs for both therapy and patient comfort. Clinical benefits of AFT include faster and more cost-effective healing of pressure ulcers, a decreased rate of hospitalizations and emergency room visits for long-term care pressure ulcer patients, decreased mortality of patients with extensive burns and inhalation injury and rapid healing and increased comfort in burn patients. The fluid support also results in a substantial decrease in the amount of caregiver effort required for repositioning patients and increased patient comfort in patients with multiple trauma and external fixation devices or deformities that require a conforming bed, and patients with cancer and bony metastasis. This article seeks to evaluate the physical differences in AFT over other mattress types and to review the published literature for this therapy modality.

Key Words: air-fluidized therapy, shear, friction, thermal resistance, evaporative capacity, skin microclimate, pressure ulcers, prevention of pressure ulcers, high-risk pressure ulcer patients, treatment of pressure ulcers

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Since the late 1960s, air-fluidized therapy (AFT) has been effectively used in many types of clinical situations. This article seeks to evaluate the physical differences in AFT over other mattress types and to review the published literature for this therapy modality.

BACKGROUND

AFT was first developed in 1968 by Hargest and Artz in an effort to effectively distribute the weight of paralyzed individuals. At that time, water beds had been introduced, which incorporated the floatation principle but did not achieve optimal pressure redistribution and had problems of maceration and maintaining appropriate body and skin temperature.[1] Unlike water beds, the new technology made use of an air- and moisture-permeable filter sheet, allowing much better management of the skin's microclimate. AFT also made use of the optimal envelopment properties of a fluid to achieve low interface pressures.

AFT has been shown in clinical studies to statistically increase the rate of pressure ulcer healing over other mattress types[2–7] and provides cost-effective pressure ulcer treatment.[3–6,8–10] This therapy incorporates compressed air that passes through a diffuser board beneath the bead bath to ensure uniform flow upward. The vertical airflow then suspends 75 to 150-μm-silicon-coated ceramic beads contained within a polyester sheet with a pore size of 37 μm. The suspended beads take the properties of a fluid, and the patient's body floats to an immersion level of ~70% to 75% depending on his or her body composition. The interface pressures continue to be much lower than those on most of the other support surfaces that have been developed even several decades later.[11] These lower pressures decrease the likelihood of capillary closure in the wound bed or at-risk tissue, thus increasing the nutrient and oxygen exchange, and reducing trauma and tissue damage secondary to localized high pressure. Lachenbruch and Kennerly[11] also reported that, because the beads in an air-fluidized bed are free to move relative to one another under the polyester sheet, there is a reduction in static friction on the skin (and probable shear within the tissue) as compared with surfaces with fixed components. The reduced level of shear imposed by the surface is actually a fundamental characteristic of a fluid; when the body slides across a conventional surface, it pushes back on the skin in the form of static friction and shear within the tissue. On fluids, the surface itself is free to flow and reconfigures to reduce these stresses instead of imposing them on the body. In other words, the forces that build up cause the surface to distort rather than the body.

Therefore, there are two fundamental advantages of fluid over conventional solid support—optimal envelopment and very low friction and shear stresses—that have allowed this technology to maintain a therapeutic advantage over the years.

AFT has several other additional benefits over other treatment surfaces. The fact that the fluid bath does not resist patient movements makes it easier for patients to move themselves with an over-bed frame. The amount of force required by caregivers to reposition and move patients is also reduced. Second, the porous nature of the coverlet of the bed allows fluids to pass into the beads in which they are sequestered and fall to the bottom of the bath, and then they can be removed with normal cleaning. The flow of air at the diffuser board level then desiccates bacteria.[12,13] Additionally, the risk of maceration of wounds is reduced and contaminated fluids are transported away, maintaining a clean dry surface even for the patient with heavy wound exudates.

These properties have made AFT an ideal surface for adult and pediatric patients with burns, patients with pressure ulcer, patients with multiple trauma, patients undergoing flap or skin grafting procedures, contracted patients, and patients with many other medical conditions.

WHY IS AFT BELIEVED TO BE EFFECTIVE?

Fluidization

The distinguishing feature of this support surface technology is its ability to create a fluid environment to support the body. Fluid

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support has several advantages with respect to reducing the mechanical stress applied to the skin and subcutaneous tissue.

The air-fluidized surface consists of fine, silicon beads—essentially high-grade glass beads —that are confined by a specialized filter sheet. When warm air is driven up from beneath with pressure sufficient to overcome their weight, the beads are lifted into the air stream and lubricated from one another. This lubrication allows the beads to move and flow independently of one another in a way that the particles that compose a conventional solid material cannot. In fact, the bath does exhibit behavior that approaches the standard engineering definition of a fluid, ie, that it is incapable of sustaining a shear stress.[14] This has relevance to the forces exerted by the AFT bath on the skin. Unlike fluids, solid materials can be visualized as being held together by microscopic springs that build up forces to resist any movement that causes distortion of the solid from its original shape. If an individual who is immersed in foam displaces a bony prominence a few inches, a force proportional to this displacement builds up that tends to drive the body back toward the original position. This is one of the major ways that shear forces can be exerted on the body, and, significantly, these forces persist as long as the displacement is maintained. If the same subject was immersed in a fluid, this small lateral displacement would be resisted with a temporary bow wave related to the fluid's viscosity, but this would quickly subside and the fluid would simply flow to relieve the buildup of stress. There would be no sustained shear stress acting on the body tending to drive the body back toward its original position. Unlike a solid, the neutral, minimum stress configuration of the bead bath rapidly resets to wherever the body happens to be located within the bath. This is true, to a very close approximation, whether a body moves in a water-filled bath tub or an air-fluidized surface.

As long as the body's displacement on an AFT surface is less than the slack in the filter sheet, the bead bath behaves as described earlier; displacements parallel to the surface cause very little sustained shear stress to be applied to the body.

TABLE 1. Selected Surface Shear Stress Measurements: Shear Measurements Were Lower on AFT Than on Other Surface Types

	Mean/95% Confidence Interval Half-Width (mm Hg)
AFT	0.47/0.21
Low air-loss or microclimate management	2.76/0.35
Self-adjusting technology (nonpowered)	6.77/3.26
Multi-density multizones foam	8.30/1.22

PHYSICAL PROPERTIES OF AFT

AFT does quite well at managing all five of the surface-related factors that are believed to contribute to skin breakdown: interface pressure, shear, friction, heat, and moisture.

Friction and Shear

The shear stress imposed on the tissue by the example cited earlier is actually driven by static frictional forces on the skin. Published measurements clearly indicate that friction imposed on the skin by activities such as raising the head of the bed are very low compared with those generated by conventional support (Table 1).[11] Logically, the resulting shear stresses in the deeper tissue between planes parallel to the surface are almost certainly much lower. Less appreciated is the fact that shear can also be generated in tissue planes perpendicular to the skin surface. These stresses are often driven by large changes in interface pressure during short distances, also referred to as high gradients in interface pressure. (Regions of high pressure, of course, tend to drive the tissue inward relative to the regions of lower interface pressure, causing shear at the interface between the planes driven by high and low pressure, respectively). It is also intuitively clear that fluid support results in minimal gradients in pressure because the fluid is free to flow and optimally conform to an irregular profile in a way that a solid surface cannot. In Figure 1, the gradient is defined as the difference in pressure at 2 points divided by the distance between those two points. For points A and B on the left side of Figure 1, the pressure at point A minus the pressure at point B is large because the pressure is concentrated at the point of highest immersion, point A. When we look at the difference in pressure between these two points in fluid support (right side of Fig. 1), the difference, hence the gradient, is minimal because the pressures at A and B are similar. Fluid support results in increased support area, reduced local pressure, and reduced pressure gradient in comparison with the trampoline-like surface on the left side of Figure 1.

Although we have no measurements of deep tissue shear on AFT, it is a logical inference from the reduced surface gradients that this should be reduced as well.

Interface Pressure

Interface pressure is reduced for a given load when the support area is increased. This is accomplished by increasing immersion, the depth of penetration into the surface and envelopment, the degree to which the surface conforms to the body.[15] (Immersion is measured as the depth of penetration below the top level of an

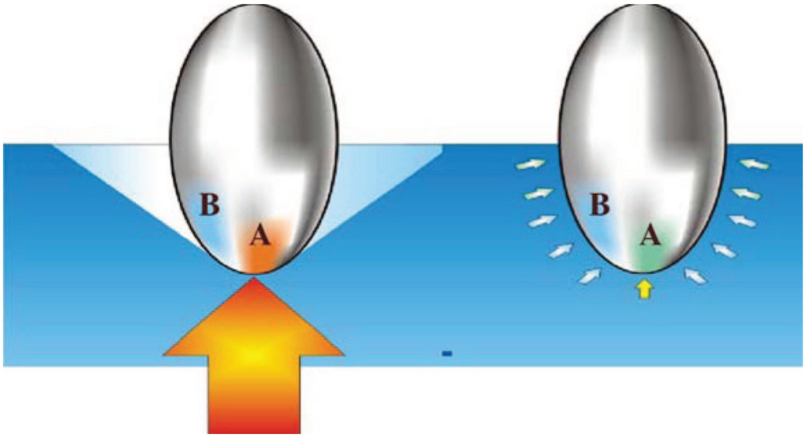

FIGURE 1. Conventional solid support (left) versus fluid support (right); note the arrow representing pressure. Pressure is inversely related to contact area; there is a more uniform pressure distribution in the right-hand side of the figure as a result of greater surface contact. The pressure gradient, or the amount of change in pressure per unit distance, ie, between A and B above, is also reduced with fluid support.

TABLE 2. Selected Surface Interface Pressure Measurements

Surface Type	Mean/95% Confidence Interval Half-Width (mm Hg)	
	Ischial Tuberosity	Heel
AFT: head at 0 degree angle	17.4/0.9	7.2/2.6
AFT: head at 45 degree angle	23.0/1.7	11.4/1.2
Powered Low Air Loss	32.8/1.2	39.6/1.9
Self-adjusting tech (non-powered air)	41.5/3.2	58.4/3.3
Multi-density, multi-zoned foam	40.8/1.1	57.1/2.3

Interface pressure measurements were lower on AFT than on other surface types. This advantage was more pronounced at the heel than at the sacrum.

Clinitron® Rite Hite® Air Fluidized Bed, http://www.hill-rom.com/usa/TotalCareSport.htm, TotalCare Sp02RT®, Clinitron CII.

Envision® E700 Low-Airloss Therapy Surface.

Flexicair Eclipse® Low Air Loss Mattress, http://www.hill-rom.com/usa/AcuCair.htm, Acucair® Continuous Airflow Therapy Surface.

ClinActiv®Zephyr System (EU).

Comfortline Ultimate® SE.

unloaded surface; envelopment is quantified for any given indenter as the contact surface area for a given level of immersion.) Very low interface pressures require both good immersion and good envelopment. However, it is possible to have good immersion without good envelopment or good envelopment without good immersion, therefore neither characteristic alone guarantees good pressure redistribution. The trampoline-like support on the left side of Figure 1 is an example of the type of support that would lead to high-peak interface pressure despite excellent immersion because the contact surface area is very small, even though it achieves the same level of immersion as the right side. (Hypothetically, a person suspended in a bath of mercury, in which only 7% of the body would immerse, is an example of excellent fluid envelopment that would not result in good pressure redistribution.)

The combination of good immersion and excellent fluid envelopment leads to relatively low interface pressures at all critical sites. As one would expect, the advantage over less conformable surfaces is most profound at regions of high curvature such as the heel. (Fig. 1). Peak sacral pressures are relatively low on AFT but only marginally better than top conventional surfaces because designers are reaching the limits of physics for flatter structures for which conformability provides less of an advantage. However, peak heel pressures are reduced to a greater extent compared with heel pressures measured on conventional surfaces. Although peak heel pressures are typically somewhat higher than peak sacral pressures on conventional surfaces, they were found to be $\sim$30% lower than peak sacral pressures on AFT (Table 2).[11] Again, this is consistent with the enhanced advantage provided by a fluid's ability to conform around the high-curvature regions of the body.

Heat and Moisture

Effective prevention and healing regimens require appropriate management of the skin's microclimate. The skin was designed to effectively function in a range of ambient environmental temperature and humidity conditions. When a person is placed on a surface, the heat and moisture that normally flow to the atmosphere are blocked and accumulated on the surface. The resulting warming[16–18] and wetting[19–21] of the skin increase the risk of breakdown. The primary goal of microclimate management is to minimize the blocking effect of the surface, and, thus, restore the skin's natural environment.

Methods have been developed to quantify the degree to which a surface interferes with and blocks the skin's interaction with the environment.[22] Performance is assessed in terms of resistances to the flow of heat and water vapor between the skin and the environment. Lower resistance values indicate higher rates of removal of heat and moisture, ie, surfaces that impede to a lesser extent the natural flow from the skin to the environment.

TABLE 3. Selected Surface Resistance to Flows of Heat and Water

Surface Type	R Dry (°C–m^2/W) Mean/SD	R Wet (Pa-m^2/W) Mean/SD
AFT at 82°F	0.07/$(n = 1)$	6.7/$(n = 1)$
AFT at 92°F	0.12/$(n = 1)$	7.0/$(n = 1)$
Low air-loss or microclimate management	0.32/0.11	241.2/128.6
Static air	0.64/$(n = 1)$	806.8/$(n = 1)$
Self-adjusting tech (nonpowered air)	0.58/$(n = 1)$	2677.1/$(n = 1)$
Foam over air (powered)	0.90/0.019	1169.2/112.92
Multi-density, multi-zoned foam	3.98/3.78	5442.5/3192

Resistance to the flows of heat and moisture were lower on AFT than on other surface types.

Clinitron® Rite Hite® Air Fluidized Bed, http://www.hill-rom.com/usa/TotalCareSport.htm, TotalCare Sp02RT®, Clinitron CII.

Envision® E700 Low-Airloss Therapy Surface.

Flexicair Eclipse® Low Air Loss Mattress, http://www.hill-rom.com/usa/AcuCair.htm, Acucair® Continuous Airflow Therapy Surface.

ClinActiv®Zephyr System (EU).

Comfortline Ultimate® SE.

Results of selected surfaces are given in Table 3 (Williamson R, et al. Unpublished data, 2007). Note that the AFT surface had the least resistance to both flows of any surface tested, indicating less of a tendency to promote the harmful accumulation of heat and moisture on the skin. From a therapeutic perspective, this translates to much greater ability to combat maceration and skin warming.

WHAT ARE THE CLINICAL BENEFITS OF AFT?

Pressure Ulcers

A variety of studies have demonstrated faster healing rates of pressure ulcers when patients have been placed on AFT,[2–7] and that AFT reduces the overall costs associated with pressure ulcer treatment.[3–6,8–10]

Ochs et al reported a higher healing rate of full thickness pressure ulcers (stage III and above) in a retrospective analysis of 664 long-term care residents who were enrolled in the National Pressure Ulcer Long-Term Care Study. This study compared the healing rate of pressure ulcers between group 1 (static overlays and replacement mattresses), group 2 (low-air-loss beds, alternating pressure, and powered/nonpowered overlays/mattresses), and group 3 (air-fluidized beds). There were 2 ways that healing rates were analyzed in this study. First, the largest ulcer from each resident was used with healing rates greatest for AFT group 3 (mean = 5.2 cm^2/wk) versus group 1 (mean =1.5 cm^2/wk) and group 2 (mean = 1.8 cm^2/wk) surfaces ($P = 0.007$). Second, healing rates also were assessed using 7- to 10-day "episodes"; each ulcer generated separate episodes that included all ulcers when residents had multiple ulcers. Mean healing rates were significantly greater for stage III/IV ulcers on group 3 surfaces (mean = 3.1 cm^2/wk) versus group 1 (mean = 0.6 cm^2/wk) and group 2 (mean = 0.7 cm^2/wk) surfaces (group 2 vs. group 3; $P = 0.0211$). An additional finding in this study for residents on group 3 was a decreased rate of hospitalizations and emergency room visits than those on group 2 surfaces (AFT = 6 of 82; 7.3%), group 1 (47 of 461; 10.2%), and group 2 (23 of 121; 19.0%, $P = 0.01$) despite significantly greater illness in residents in groups 2 and 3.[7]

Allman et al compared the effectiveness and adverse effects of air-fluidized beds and conventional therapy in 65 patients with pressure sores in a randomized controlled trial in an Urban Primary Care Medical Center. Thirty-one patients were placed on air-fluidized beds (Clinitron, Hill-Rom, Batesville, IN) and repositioned every 4 hours from 0700 hours to 2300 hours without use of other antipressure devices. Thirty-four patients on conventional therapy used an alternating air-mattress covered by a foam pad (Lapidus Air Float System, American Pharmaceal Company, Cincinnati, OH) on a regular hospital bed, and they were repositioned every 2 hours and had elbow or heel pads, as needed. Topical therapy was standardized for both groups. Pressure ulcers showed a median decrease in total surface area (-1.2 cm^2) on air-fluidized beds, but it showed a median increase ($+0.5$ cm^2) on conventional therapy ($P = 0.01$). For pressure sores ≥ 7.8 cm^2, outcome differences between air-fluidized beds and conventional therapy were greater: median total surface area change was -5.3 and $+4.0$ cm^2, respectively, and 95% CI for the difference, -42.2 to -3.2 cm^2 ($P = 0.01$). After adjusting for other factors associated with pressure ulcer outcome, the estimated relative odds of showing improvement with air-fluidized beds were 5.6-fold (95% CI, 1.4–21.7) greater than with conventional therapy ($P = 0.01$).[2]

Greer et al, in a study to assess effectiveness and costs, enrolled 17 consecutive patients with stages II, III, and IV pressure ulcers. These patients were placed on AFT beds at study day 1. All parameters observed showed positive outcomes with AFT: (1) 30-day average decreases in length of stay, (2) a 30% reduction in therapy costs, and (3) a 98% reduction in ulcer-related nursing treatment time. A subgroup of stage IV patients experienced healing without surgery or extension of expected length of hospital stay. No patients deteriorated during treatment, all improved to varying degrees and no new ulcers developed at any time during the study period.[5]

Munro et al reported a randomized controlled pressure ulcer prevention trial enrolling 40 male veterans with stage II ($n = 21$) or III ($n = 19$) pressure ulcers treated for 15 days with either AFT or conventional therapy. Although the AFT patients had larger initial average ulcer diameters (2.260 vs. 1.463 cm^2), the mean ulcer size shrank considerably with AFT therapy (mean change in area -1.158 cm^2) and increased with conventional therapy (mean change in area $+ 2.051$ cm^2).[6]

What are the Cost Benefits of Using AFT for Pressure Ulcers?

AFT is cost-effective in the treatment of severe pressure ulcers (stage III and above) in acute care,[6] in long-term care,[4,8] and in home care.[3] In the acute care study reported by Munro et al,[6] the costs of skin care supplies was statistically lower in the AFT group ($6.70 vs. $17.85) in this study (not including specialty bed rental). Also in acute care, Barnes and Rutland[9] reported a worst-case stage IV pressure ulcer patient admitted to acute care with average supply costs of $131.69 before AFT plus 240 minutes of nursing time reducing to $94.38 (both values include specialty surface rental) and 45 minutes of nursing time.

Cuddigan and Ayello[8] reported a cost assessment for pressure ulcer treatment in long-term care that estimated the cost of care at $122 per day, which includes supplies, nursing time, and group II bed rental, as compared with $182 cost per day for AFT treatment. Despite higher per day costs, AFT was shown to be cost-effective when compared with standard dressings and low air-loss therapy because of faster healing times, even in smaller wounds (5 cm^2 of initial surface area).[8]

Bristow et al studied 10 long-term care patients with stage III and IV pressure ulcers who had not responded to other therapies for efficacy of healing and cost justification. Total weekly costs to treat patients that included nursing time, nursing costs, dressings, and linens were studied for a 2-week period of active care and were found to be reduced by 50% during that period. AFT-treated patients healed the majority of their wounds in 60 days, despite multiple diagnoses, incontinence, frailty, poor nutritional status, and immobility.[4] Bird et al[10] describe AFT use in a long-term care skilled nursing unit and report a reduction in healing time, wound dressings and treatments, and nursing time.

Strauss et al studied 112 patients with stage III or IV pressure ulcers randomly assigned to 36 weeks of either home air-fluidized bed therapy that included the services of a visiting nurse specialist as long as the patient's wound remained open or conventional therapy. When compared with patients in the control group, patients receiving air-fluidized bed therapy spent fewer days in the hospital (11.4 vs. 25.5 days, $P < 0.01$) and used fewer total inpatient resources, as reflected both in charges ($13,263 vs. $25,736, $P < 0.05$) and in Medicare DRG and physician payments ($6646 vs. $12,131, $P < 0.05$). Total resources used (inpatient and outpatient) were lower for patients treated with air-fluidized bed therapy, but because of high variation, the difference was not statistically significant.[3]

POSTOPERATIVE CARE IN THE PATIENT UNDERGOING FLAP SURGERY

Patients who undergo graft reconstruction for primary closure of pressure ulcers consent for a procedure that resects a segment of muscle and skin, which has a movable vascular supply to be placed on a wound bed in hopes of immediate wound closure. The areas of the body in which flaps can be taken are limited; therefore, when a graft fails, it is a devastating event as the tissue is gone, and to be grafted again, patients must have other viable tissue in other anatomic sites. Besides absolute flap necrosis, any critical reduction of microcirculation or disturbed wound healing in the early postoperative period may lead to increased fibrosis and scarring that increases the risk of ulceration in that same anatomic location in the future. AFT has been used extensively in postoperative care of patients undergoing flap reconstruction. The amount of time required for flap stabilization is dependent on the size of the flap and other patient-specific variables but is normally between 2 and 6 weeks.[23] The advantage of using AFT in this patient group is that patients can lie on the graft immediately postoperatively,[23] and the shear and friction that may cause trauma of the flap including microcirculatory trauma and absolute dehiscence is minimized, and because of low interface pressures, capillary profusion is maintained, which combines and yields better overall flap survival.[23–24]

Nursing Care and AFT Treatment

Patients who rest on the AFT report that they are comfortable,[10,24–28] and burned patients experienced a longer duration of sleep using AFT.[29] Nursing and medical care in general is facilitated by the AFT bed.[10,24–25,28] The turning schedule can be lengthened in some cases from an every 2-hour schedule to an every 4-hour schedule. However, even though turning the patient is not required as frequently with AFT for pressure redistribution, the patient must be repositioned to retain lung expansion, pulmonary clearance, and joint mobility.[28] One staff person may be able to perform dressing changes, or other bedside procedures, or care by prepositioning the patient in the bed and then turning the fluidization off, whereby the beads conform to the patient, holding the patient in place in whatever position they were placed in. For example, sacral wounds are more easily dressed by turning the patient on the side and then pressing down on the bed at the area just under the wound, and turning off the fluidization, which creates an open work area.

Monitoring for early signs of dehydration including intake and output assessment and electrolyte balance are required. Patients should be given adequate hydration to balance the evaporative water loss created by constant airflow against their skin.[30–32]

AFT for Patients With Extensive Burns

The Clinitron bed, shortly after its development, was used to treat burn patients with excellent success.[1,11,25,33–36] AFT promotes rapid drying of wounds, accelerated epithelialization of the superficial burns, reduced the periods of the wound preparation for autodermoplasty for deep burns, and prevention of rejection and lysis of the replanted grafts due to pressure necrosis.[33–35] Unlike most conventional surfaces, the AFT bed temperature can be adjusted for comfort or the maintenance of core body temperatures. This is a significant advantage in patients with large burns who may have large fluctuations in body temperature.[32]

Scheulen and Munster compared 44 burn patients receiving AFT with 40 burn patients treated with conventional therapy. Half of the AFT-treated group also suffered inhalation injury compared with 40% of patients in the conventional therapy group. Mortality was 20.5% in the AFT group and 35% in the conventional therapy group, which did not reach significance; however, if only the patients with inhalation injury are assessed, 18 of 22 patients (81.8%) survived on AFT, whereas only 7 of 16 (43.8%) survived with conventional therapy, $P < 0.05$.[36]

Before the use of AFT, the choice of skin donor sites was limited due to maintaining turning surfaces, which leads to less possible autografting in a single operative procedure. AFT allows donor sites to heal (average of ~9 days)[29] when placed directly on the surface, which maximizes the amount of grafting in any one surgical procedure.[29,37] This allows 18% to 25% more total body surface area available for potential donor sites without subsequent complications.[36,37] Bacterial cultures of the silicon microspheres performed by Newsome et al[29] indicated that after a 24-hour period of fluidization, all cultures were sterile, which agrees with the initial study by Sharbaugh and Hargest,[12] which showed that bacteria die primarily by sequestration into fluid that forms clumps of microspheres that fall to the diffuser board at the bottom of the bath in which they are dessicated by airflow. This is a significant clinical advantage in this extremely compromised patient population.

Other Clinical Applications of AFT

Other published applications of AFT include pain management for patients with chronic cancer, especially those with bony metastasis, pathologic fractures, and skin breakdown.[27] Aggressive pressure ulcer prevention has been used for early lesions in patients who are contracted and unable to lie in a flat position[38] and in very high-risk postoperative cardiovascular surgical patients who have undergone complicated cardiovascular surgery procedures, are ventilated, and on multiple vasopressors (Jackson M, et al. Unpublished data, November 2009). General surgery patients managed on AFT beds at 32°C had less urinary protein catabolism, which is thought to be the result of decreased shivering after operation; thus, a reduction in postoperative stress[39–41] AFT has also been used in cases of multiple trauma. Shore-Myers and Mann-Distaso[42] reported that orthopedic patients requiring external fixation devices have been more comfortable and required significantly less pain medication and received pressure ulcer prevention, which is a very common problem for the immobilized orthopedic patient.

What are the Contraindications for AFT?

Patients with unstabilized spinal cord injury should not be placed on AFT beds. The Clinitron Rite-Hite bed should be used with lower truncal/lower extremity wounds only because the therapy is only present in the lower section of the bed. Additionally, the weight limits of the Clinitron II AFT bed is 215 lbs and Clinitron Rite-Hite AFT is 350 lbs. These weight limits should be maintained in clinical practice.[43]

WHAT ARE THE OTHER CONCERNS WITH AFT TREATMENT?

1. About 3% to 4% of patients who are treated with AFT experience dehydration.[2,29] Evaporative water loss through intact skin has been found to be strongly dependent on the temperature of the bead bath. Studying healthy volunteers, McNabb and Hyatt determined the mean fluid loss at a bath temperature of 86°F to be 520 mL/m^2 in 24 hours, similar to that on a standard hospital bed (480 mL/m^2 in 24 hours). The loss was found to increase to 663 mL/m^2 in 24 hours at 88°F and 1004 mL/m^2 in 24 hours at 94°F. The figures were similar among a group of 14 inpatients (617 mL/m^2 in 24 hours at 88°F and 938 mL/m^2 in 24 hours at 94°F). Interestingly, 59% of the losses measured on the inpatient sample were within 100 mL/m^2 in 24 hours of the regression line from the healthy subjects and 81% were within 150 mL/m^2 in 24 hours, suggesting that measurements on normal subjects track closely with those of actual inpatients.[30] More recently, Lachenbruch (unpublished data, August 2009) measured slightly lower levels of weight loss among healthy volunteers under similar conditions. In this study, the figures were 473 mL/m^2 in 24 hours at 88°F (<28.7% compared with the healthy subjects of McNabb and Hyatt) and 915 mL/m^2 in 24 hours at 94°F (8.7% less).[44] Michaels and Sorenson measured weight loss of a single healthy subject for 1 week in an air-fluidized bed at 96.8°F (36°C). The mean loss, 1524 mL/m^2 in 24 hours, was 26.4% less than the 1123 mL/m^2 in 24 hours measured by Lachenbruch at the same temperature.[31]
2. The capacity for evaporation of moisture present from open skin lesions (not the withdrawal of moisture across intact skin) actually seems to be an order of magnitude higher than these measured loss rates, with measured values of ~16,000 g/m^2 in 24 hours. This figure is independent of temperature across the typical bath temperature range of 88°F to 100°F under typical indoor relative humidity conditions (Williamson R, et al. Unpublished data, 2007). The increase in water loss with temperature observed in all 3 studies seems to reflect the well-established increase in perspiration with skin temperature.[45] Each of these studies also noted significant patient-to-patient variation in loss rate, which is also consistent with the high level of patient-to-patient variation in perspiration rates for a given stimulus.[46] It seems that the potential to evaporate moisture significantly exceeds the quantity of moisture that is likely to be available on the skin for evaporation but for patients who are sweating profusely or otherwise losing fluids, AFT is typically capable of evaporating the bulk of what is produced, with a probable exception of burn patients. This suggests the need to closely observe patients for profuse sweating or for early signs of dehydration and careful monitoring of fluid intake and output.
3. Patients with pulmonary congestion should be treated with the Clinitron Rite-Hite bed system rather than Clinitron II because they require a back support to promote a productive cough. These patients may also benefit from an aggressive respiratory care plan including chest physiotherapy.[32]
4. Confusion or disorientation has also been experienced with AFT therapy, especially when patients have been placed in the prone position. In patients undergoing elective procedures, such as flap surgery, this has been minimized by allowing patients to experience the AFT bed before operation.

5. If damage occurs to the bed's coverlet, the ceramic microspheres may escape from the bed. This problem has been countered by immediately taping any damaged area and seeking assistance from the manufacturer's service technicians on discovery for a replacement coverlet.
6. Patients may have difficulty in achieving independence, as ingress and egress is difficult on an AFT bed, and most patients are stepped down to a conventional surface to facilitate rehabilitation.
7. In the home care setting, some patients have reported increasing room temperature, particularly when no air-conditioner is present, because the AFT bed does add a measure of additional heat into the room.
8. Aggressive pulmonary hygiene has also been suggested in this patient group, primarily because of the lack of overall mobility that may lead to atelectasis. Increasing fluid intake to at least 2400 mL/day if not contraindicated has also been suggested by Lucke and Jarlsberg[32] to decrease the viscosity of pulmonary secretions and allow better clearance.

SUMMARY

In summary, AFT has been shown to support the body in a unique fluid-like environment that is fundamentally different from the support provided by surfaces made up of conventional solid materials. Shear stresses associated with movement of the body across a conventional surface build up and tend to drive the body back to its original position. On AFT, these shear forces are not sustained because they are relieved by the flow of the fluid. Interface pressures and pressure gradients at the bony prominences are also very low. Finally, the degree to which the AFT bed blocks the natural flows of heat and humidity between skin and environment is much lower than other surface types such as foam or low air loss, allowing the microclimate of the skin to be closer to the conditions it would be subjected to in a standard open-air environment.

Clinical benefits of AFT include faster healing of pressure ulcers, which has been shown to be cost effective; a decreased rate of hospitalizations and emergency room visits for patients with pressure ulcers; decreased mortality of patients with extensive burns and inhalation injury; and rapid healing and increased comfort in burn patients. A substantial decrease in the amount of healthcare provider effort required to manage these critically ill patients because of ease of repositioning has been documented. Increased patient comfort is especially seen for patients with multiple trauma and external fixation devices, deformities that require a conforming bed, and patients with cancer with bony metastasis. As with any therapy, good patient selection is needed, and clinical assessment is required to achieve optimal outcomes.

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