Comparing Lateral and Longitudinal Air Cylinder Configurations in Support Surfaces

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The majority of powered support surfaces on the US market have air cylinders oriented in a lateral or side-to-side configuration; a minority of powered surfaces have air tubes oriented in a longitudinal or head-to-foot configuration. This imbalance of products leads to the assumption that lateral configurations are better at pressure management than longitudinal configurations. This assumption requires testing.

Objective testing in a laboratory setting, with pressure mapping as an objective measure, might help to prove or disprove the assumption of effectiveness related to the configuration of air cylinders in support surfaces.

GOAL: We set out to determine in a laboratory setting whether lateral cylinder configurations were, indeed, better at managing pressure than longitudinal configurations. Pressure management performance was quantified by recording interface pressures in each of three settings:

1. Pressures with the bed in the flat position – The measurements of maximum pressures were recorded in a flat position after the head of the bed had been elevated to 30° ("returned to flat" position). Interface pressures change as the patient moves. Recording maximum pressures after the patient raises and lowers the head of the bed may be more representative of the "real world" as it takes into account accommodation of the support surface and the patient's tissues after movement.
2. Amount of surface accommodation to movement – Difference in peak pressures between the returned-to-flat position and the initial flat position measure how much accommodation occurs between the bed and the patient after raising and then lowering the head of the bed. This was calculated on a percentage basis.
3. Pressures with the head of the bed (HOB) elevated 30° ("gatched") – Sacral pressures increase as the head of the bed is elevated. Since this position is often used for patient comfort, during meal times, and for self care needs, knowing the effects of a support surface on the sacral area in this position is helpful to the clinician.

METHOD: Although interface pressure mapping does not always directly correlate to subcutaneous pressures, it does provide a somewhat objective method of comparing the performance of various surfaces on the same body, and comparing trends in various bodies on the same surfaces. For this study, we used the Force Sensing Array (FSA) by Vista Medical, Winnipeg, Canada.

Surfaces used: Two surfaces by established, market-leading support surface manufacturers and currently in common use in the United States were studied. Both were powered surfaces of similar construction using a pump to maintain constant inflation of air cylinders. One had the cylinders in a lateral configuration and the other had cylinders in a longitudinal configuration.

Each surface was placed on the same bed frame constructed with a flat solid pan and electric head elevation. Consistent degree of head elevation was determined by a self-leveling protractor placed on the horizontal bedrail as the head was elevated.

DESIGN: We pressure mapped two subjects, the first a 5' 3", 120 lb. female, and the second a 5' 10", 180 lb. male. Each of these subjects wore similar cotton clothing, removed all objects from their pockets, and removed their shoes. They were mapped without using pillows.

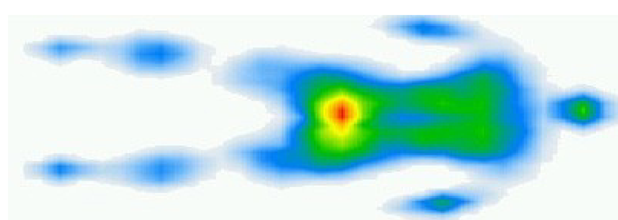
Each mattress was set up per manufacturer's instructions regarding orientation on the bed frame, power supply, and inflation level.

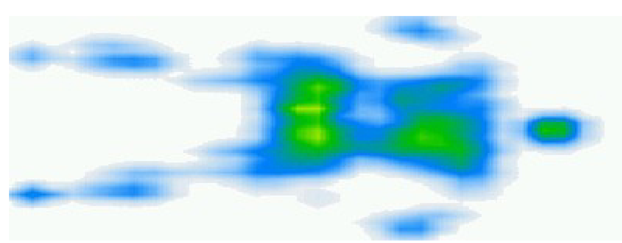
The mat for the FSA was placed on the support surface, the subject was placed on the mat, wrinkles in the mat were straightened out, and the patient was oriented such that the hip was lined up with the point of rotation of the hip gatch in the bed frame. This was done to minimize sliding of the patient toward the foot of the bed when the head was elevated to 30°. Readings were taken in the initial flat mode, after the head was elevated to 30°, and when the bed was returned to a flat position.

The FSA reads in millimeters of mercury (mm. Hg.) and provides a print out of the pressures over the entire support surface simultaneously. The FSA calculates and reports the average pressure of the sensors included in the reading, the maximum pressure recorded, and the number of sensors included in the reading. The number of sensors provides an indication of the immersion of the subject into the surface; the more sensors involved in the reading, the greater the area that is involved in managing the pressure of the subject.

RESULTS: The values from the FSA recordings used for the calculations below are shown in Table 1 for the 5' 3" 120 lb female, and in Table 2 for the 5'10" 180 lb male.

1. Pressures with the bed in the flat position ("returned to flat") – Longitudinal cylinders gave lower peak pressures than the lateral cylinders for both subjects. The pressures on the longitudinal cylinders were 41% better on the female subject (100 vs. 59) and 19% better on the male subject (76 vs. 64).





As an illustration, the mappings for the female subject are shown above. In the upper picture, the maximum pressures on the lateral cylinders are at least 100 mm Hg. (the FSA does not record pressures higher than 100). In the lower picture, the maximum pressure on the longitudinal cylinders was 59.

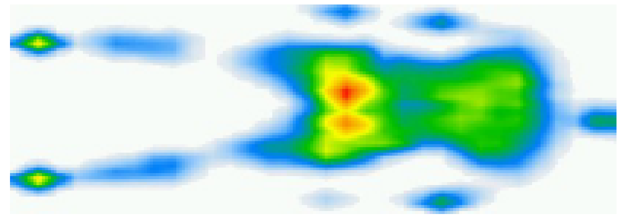
Average pressures over the surfaces were lower on the longitudinal tubes on both subjects in all positions except one, where the pressures on the longitudinal were slightly higher (5%) than on the lateral tubes.

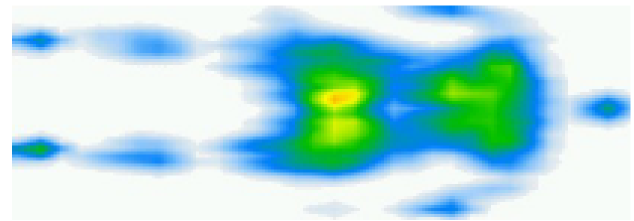
Immersion of each subject differed. There was a marked difference in the immersion of the heavier subject – 421 sensors in the longitudinal configuration compared to 382 sensors in the lateral configuration. There was no appreciable difference in the amount of immersion of the lighter patient into the two surfaces.

2. Amount of surface accommodation to movement – This was calculated using the difference in peak pressures between the returned-to-flat position and the initial flat position. When the bed was flattened after gatching to 30°, peak pressures on the longitudinal cylinders decreased 3% for the female subject and 25% for the male subject compared with peak pressures before gatching. Peak pressures on the lateral cylinders increased 21% for the female subject and 31% for the male subject. This would be significant in the "real world" setting, as it demonstrates what the sacral pressures would do as the head of the bed is elevated and lowered.

3. Pressures with the head of the bed elevated 30° ("gatched") – Longitudinal cylinders gave lower peak pressures than lateral cylinders for both subjects. The pressures on the longitudinal cylinders were 33% better for the female subject (80 vs. 60) and 21% better for the male subject (100 vs. 79).

The following mappings are of the male subject in the 30° gatched position. The top picture illustrates the pressures on the lateral cylinders, and the bottom picture illustrates the pressures on the longitudinal cylinders. The maximum pressure on the lateral cylinders again exceeds 100, while the maximum pressure on the longitudinal cylinders was 79.





CONCLUSIONS: Lateral cylinder support surface configurations do not appear to offer significant benefits to pressure management over longitudinal support surface cylinder configurations. In fact, the longitudinal appears to be at least as good as, if not better than, the lateral cylinder configuration in managing pressures in the supine and 30° elevated positions. When the head of the bed was returned to the flat position after being elevated, the maximum pressures on the body increased on the lateral cylinders, and decreased markedly on the longitudinal cylinders.

TABLE 1: Subject 5' 3" 120 lb. female

		Lateral Tube Configuration	Longitudinal Tube Configuration
Returned to flat	**Maximum pressure**	100	59
	Average pressure	16.4	14.6
	# of sensors	315	305
Initial Bed Flat	**Maximum pressure**	83	61
	Average pressure	16.1	15.2
	# of sensors	306	305
Change in maximum pressures following bed position change (Returned to flat – Initial bed flat)		+17, pressures increased 21%	–2, pressures decreased 3%
HOB elevated 30°	**Maximum pressure**	80	60
	Average pressure	15.6	14.1
	# of sensors	322	316

TABLE 2: Subject 5' 10" 180 lb. male

		Lateral Tube Configuration	Longitudinal Tube Configuration
Returned to flat	**Maximum pressure**	76	64
	Average pressure	19.9	19.3
	# of sensors	390	406
Initial Bed Flat	**Maximum pressure**	58	80
	Average pressure	20.4	21.4
	# of sensors	373	383
Change in maximum pressures following bed position change (Returned to flat – Initial bed flat)		+18, pressures increased 31%	–16, pressures decreased 25%
HOB elevated 30°	**Maximum pressure**	100	79
	Average pressure	20.7	18.4
	# of sensors	382	421

Todd Batt, BSME, is a graduate of the Mechanical Engineering Department of Clarkson University in Potsdam, NY. He has worked in the field of Rehabilitation Technology in both patient service and research since 1994, and is currently employed by the South Carolina Vocational Rehabilitation Department in Columbia, SC. He is a member of the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA).