LINET

VIRTUE OF AIR: A CLOSER LOOK AT ALTERNATING SUPPORT SURFACE DESIGNS FOR PRESSURE RELIEF







BACKGROUND

Pressure injury prevention for patients involves a combination of patient assessment, regular monitoring and repositioning, control over nutrition and hydration, and choosing the right aids and support surfaces. The prevalence of pressure injuries is not solely dependent on support surfaces; they are one piece of the pressure injury prevention puzzle.

Choosing the right support surface for a patient is challenging due to the patient's medical conditions. Each patient requires a tailored approach, considering factors like weight, size, existing pressure injuries, and overall health status. The wide variety of mattress options, each with specific features, further complicates the decision-making process, as healthcare providers must balance the benefits and limitations of each mattress to meet both immediate and long-term needs of their patient population.

This white paper will investigate alternating support surfaces and the complexities that caregivers face when identifying the most appropriate surface to meet patients' needs in their organizations. Understanding the different designs of alternating support surfaces adds another layer of difficulty. These support surfaces incorporate various technologies, such as 2-cell versus 3-cell systems, integrated air compressors, and moisture control features. Healthcare providers need to comprehend these differences to effectively use the support surfaces. Additionally, the constant evolution of mattress technology requires ongoing education and training to ensure optimal patient care and prevent complications from improper use or malfunctions.

CONCLUSION

When examining different designs of alternating support surfaces, while there are differences in pressure relieving capabilities, all designs serve the primary purpose of preventing pressure injuries. It is important to remember that support surfaces are just one part of pressure injury prevention, and without proper nursing care, patients can still develop pressure injuries on any support surface. Support surfaces help reduce risk factors contributing to pressure injuries, such as the amount and duration of pressure, moisture vaporization, and friction and shear forces. They also vary in how they are used in hospital settings, especially when hospitals face nurse shortages and budget constraints. The differing patient acuity levels across the healthcare organization also need to be taken into consideration as one surface type does not meet all patient's needs.

When we look at the variety of departments across healthcare facilities, we can see that patients have diverse care needs and require different types of support surfaces, not only based on pressure relief. For example, in the intensive care unit (ICU) a higher specification of mattress that can control microclimate control or support proning i.e., individual cell deflation could be appropriate. Acute care departments may prefer more versatile mattresses such as hybrids that can support the step-up/step-down approach to pressure injury prevention. And in long-term care the focus may be around comfort and options for increased pressure injury prevention.

LINET's portfolio offers a wide range of alternating support surfaces to meet healthcare organization and patient needs. Pressure mapping confirmed the effectiveness of the 3-cell system, showing that the 3-cell alternating system provides 44% more pressure relief than 2-cell systems. In summary the premium Virtuoso family provides highest pressure relief and superb features for the most demanding departments, while the Air2Care family offers great value with innovative options like the integrated compressor in the Essenza 300 for acute care settings. The HybriMatt family offers the best solution for hospitals aspiring to cover most patients with a single mattress, providing high acceptance through gentle alternation without the need of equipment handling. Also, there should be mentioned that both families of Air2Care and Virtuoso offer overlays and cushions for completing 24-hour care.

The science and technology behind alternation

The principle of alternating pressure dates to 1961 when a study conducted by Exton-Smith demonstrated that, when pressure is eliminated at frequent intervals it allows circulation back to ischemic tissues and prevents pressure injuries. This was observed by prevalence of pressure injuries in patients who moved during sleep (EXTON-SMITH AN, 1961). This study laid the foundations for the design of alternating mattresses, which redistribute pressure by alternately inflating and deflating air cells within the mattress. This mechanism helps to reduce prolonged pressure on any area of the body, continuously shifting the points of pressure, thereby enhancing blood circulation, and reducing the risk of tissue breakdown. Consequently, alternating mattresses have become an essential tool in the management and prevention of pressure injuries.

Another key reason for developing alternating mattresses is the understanding that time is a crucial factor in the development of pressure injuries. Skin can tolerate pressure for shorter periods better than for extended periods of time. Therefore, the length of cycle time is critical (The cycle time is the duration for the mattress to complete one full cycle of inflation and deflation of its cells). For example, a 10-minute cycle within a 2-cell system means each cell is inflated for 5 minutes and then air/pressure transfers into the next cell. The development of cycle times also considers patient comfort, as some patients cannot tolerate short cycle times, prompting some systems to offer also longer cycles to increase patient tolerance of alternating mattresses, and compliance with pressure injury protocols.

Alternating pressure mattresses always require a power source, an air compressor, to inflate and deflate the cells. Advances in technology over the years have led to compressors that can recognize different mattress models, have sensors to identify low pressure, and are fitted with alarms to alert caregivers of faults or issues. They can be also equipped with batteries to provide active therapies during patient transportation around hospital departments. Additionally, in the last decade, compressors have gained the smart ability to automatically set the pressure within the cells based on the patient's weight or change mode based on patient’s movement on the surface.

Choosing a support surface for pressure injury prevention

Alternating support surfaces are a crucial component in the prevention of pressure injuries, particularly for individuals who are bedridden or have limited mobility. However, the implementation of alternating support surfaces for specific patients is not always straightforward.

According to the latest EPUAP/NPIAP/PPPIA Clinical Guidelines from 2019, the support surface should be selected based on the patient’s needs, considering the following factors:

1. Level of immobility and inactivity
2. Need to influence microclimate and shear reduction
3. Size and weight of the patient
4. Number, severity, and location of existing pressure injuries (PIs)
5. Risk of developing new PIs

Considering these factors, caregivers should select the most suitable surface based on the patient's overall needs, rather than solely on the risk of developing pressure injuries (PI). It is important to note that alternating pressure air mattresses can limit patient movement, which may contribute to the development of pressure injuries instead of preventing them.

LEVEL OF IMMOBILITY AND INACTIVITY

Alternating support surfaces provide periodic movement under the patient's body, supplementing bodily movement for patients who cannot fully relieve pressure themselves. These surfaces include mattresses, overlays, or cushions. If a patient is mobile or able to partially offload their body, alternating mattresses can limit movement and may require more effort for self-mobilization compared to foam mattresses.

But when an alternating mattress is used according to patient needs, it can reduce prevalence of PI. This was investigated in Sauvage's study, where was observed, that a patient with limited mobility has 7.5 times higher chance of developing a pressure injury on standard foam mattress in comparison with alternating pressure air mattress (Sauvage P, 2017).

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(Sauvage P, 2017)

NEED TO INFLUENCE MICROCLIMATE AND SHEAR REDUCTION

Alternating mattresses can influence microclimate and shear, especially pressure air mattresses and overlays. These surfaces are always powered via an air compressor, allowing features such as air flowing under the patient's body (MicroClimate Maintenance feature) or increase pressure in mattress to reduce shear and friction forces during repositioning (MAX pressure feature).

SIZE AND WEIGHT OF THE PATIENT

The size and weight of the patient needs to be considered to prevent pressure injuries caused by 'bottoming out' and to facilitate repositioning. Mattresses must have sufficient dimensions and be designed based on the dimensions of the hospital beds where they will be used. In relation to patient weight, alternating support surfaces allow caregivers to set or adjust the internal pressures in the cells to accommodate heavier patients.

NUMBER, SEVERITY, AND LOCATION OF EXISTING PRESSURE INJURIES

Patients who have an existing PI or have developed HAPI's are at a higher risk of developing additional PIs. According to EPUAP/NPIAP/PPPIA 2019 alternating support surfaces should be considered for these individuals, as they can provide preventative measures such as individual cell deflation to offload high-risk areas of skin damage whilst providing active pressure relief to support pressure injury prevention (EPUAP/NPIAP/PPPIA, 2019).

Alternating support surfaces should be considered for individuals with pressure injuries
(EPUAP/NPIAP/PPPIA, 2019)

RISK OF DEVELOPING NEW PRESSURE INJURIES

In order to identify, if an individual is at risk of developing a pressure injury, EPUAP recommend that caregivers use a valid and reliable risk assessment tool (EPUAP/NPIAP/PPPIA, 2019). For individuals that are at high-risk or very high-risk an alternating mattress should be considered to support the prevention of PIs, as they have offloading and microclimate capabilities. However, this may not always be the most appropriate solution as the choice of surface depends on multiple factors as previously discussed.

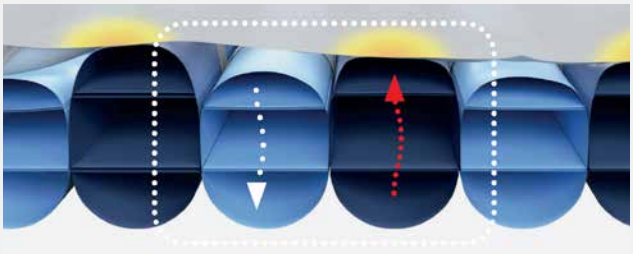
Are all designs of alternating support surfaces the same?

Alternating support surfaces currently available on the market have assorted designs and modes of action. There is still insufficient evidence to recommend any specific design as having greater efficiency in terms of preventing pressure injuries. (EPUAP/NPIAP/PPPIA, 2019) In the table below we will explore the different design features of alternating support surfaces from different perspectives.

DESIGNS OF ALTERNATING SUPPORT SURFACES					
Pressure air support surface					Hybrid support surfaces
Mattress Replacements			Overlays	Cushions	Mattress Replacements
2-cell	3-cell	4-cell	2-cell	2-cell	2-cell

COMPARISON OF ALTERNATING SUPPORT SURFACES BASED ON CARRIER MEDIUM

PRESSURE AIR ALTERNATING SURFACE



Alternating pressure air mattresses (APAMs) are designed with air carrier medium, which circulate inside the cells and are powered via an air compressor.

PROS	CONS
• Higher effect of offloading. • Suitable for all risk levels of developing pressure injuries. • Allows individual cell deflation. • Higher moisture vaporization. • Can control patient's Microclimate.	• Cannot work without a compressor. • Risk of bottoming out if the pressure inside the mattress is insufficient. • May limit movement for mobile patients. • Time-consuming preparation of mattress. • Waiting time for inflation of the mattress.

HYBRID ALTERNATING SUPPORT SURFACE



Hybrid alternating support surfaces are designed as passive foam mattresses with the ability to alternate. The cells are designed with foam core and air carrier medium, where air circulates only when is connected to compressor.

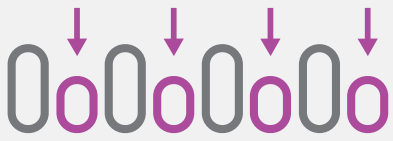
PROS	CONS
• Gentle alternation. • 2-in-1 mattress. • Save time in stepping up or down in pressure injury prevention. • Can work without a compressor in passive mode. • Continuous protection against bottoming out. • Comfortable.	• Lower pressure relief. • Less effective moisture vaporization due to foam. • May not provide sufficient protection for very high-risk patients. • Does not allow individual cell deflation.

COMPARISON OF ALTERNATING SUPPORT SURFACES BASED ON TYPE OF THE SURFACE

ALTERNATING MATTRESS REPLACEMENT	ALTERNATING OVERLAY	ALTERNATING CUSHION
		
Mattress replacements are full mattresses placed on the bed platform, with a compressor. Some alternating compressors can be integrated into the bed platform and be ready when the mattress is attached. Alternating pressure air mattresses are more effective than alternating pressure air overlays, particularly in reducing stage II and higher-pressure injuries (Manzano F, 2013).	An overlay is a top layer placed over a foam mattress. An alternating pressure air overlay requires a quality base mattress, as the base mattress can influence the overlay's performance.	An alternating cushion is placed on the chair to support 24-hour care. Some brands allow the use of the same compressor as for mattress replacement. Using an alternating pressure air cushion can be recommended for supporting pressure injury healing in individuals who are seated in a chair or wheelchair for prolonged periods, particularly when the individual is unable to perform pressure-relieving maneuvers. (EPUAP/NPIAP/PPPIA, 2019).

Alternating pressure air mattresses are more effective than alternating pressure air overlays, particularly in reducing stage II and higher-pressure injuries.
(Manzano F, 2013).

COMPARISON OF ALTERNATING SUPPORT SURFACES BASED ON NUMBER OF ALTERNATING CELLS

2-CELL ALTERNATION	3-CELL ALTERNATION	4-CELL ALTERNATION
		
2-cell alternation provides **50% body support during alternation**. The cells **can be deflated only partly**, because of risk of bottoming out.	3-cell alternation **supports 66% of the body area**. This design involves cells which **can be completely deflated**. The inflated cells keep the body supported, protecting the patient against bottoming out.	4-cell alternation **supports 75% of the body**. Cells can be fully deflated because body is supported by inflated cells, but **pressure relief area is smaller compared to 3-cell and 2-cell design**.

LINET solutions of alternating support surfaces

LINET has many years of experience with alternating mattresses. Over time, they have incorporated a wide range of alternating support surfaces to aid caregivers in decision-making and to meet patients' needs. As a global company, LINET delivers support surfaces to various countries, accommodating different pressure injury prevention strategies and financial settings. This extensive experience and adaptability make LINET a trusted provider of advanced alternating support surfaces worldwide.

At LINET, we offer a range of advanced alternating support surfaces tailored to meet diverse patient needs. Our product lines include the HybriMatt Family of hybrid mattresses, the Air2Care Family featuring 2-cell alternation, and the Virtuoso Family with 3-cell alternation. Each family of products has specific features designed to optimize patient care. Below is an overview of each family and their feature.

Feature / Product			HybriMatt Family	Air2Care Family	Virtuoso Family
Therapy mode	Active	2 cell alternating	✓	✓	
		3 cell alternating			✓
		Cycle duration (min)	10 12 15 20 25	10 15 20 25	7.5
		Zero pressure			✓
	Reactive	(e. g. viscoelastic foam)	✓		
Constant low-pressure mode			✓	✓	✓
Automatic Pressure setting				✓	
MicroClimate Maintenance			✓		✓
Extra support against bottoming out while sitting				Fowler boost	Fowler boost
Mattress type	Integrated mattress		✓	✓	
	Mattress replacement		✓	✓	✓
	Mattress overlay			✓	✓
	Active seat cushion			✓	✓
Category of Pressure Injuries			I-IV	I-IV	I-IV

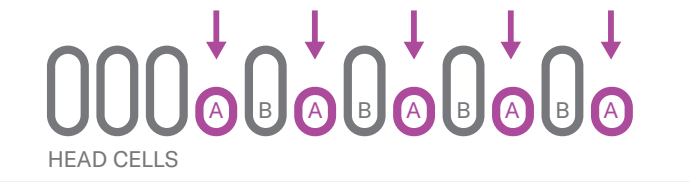
Alternating mattresses through lens of pressure mapping

To better understand alternating support surfaces, pressure mapping was conducted using an XSensor Pro high-resolution pad. Pressure mapping was performed with mattresses placed on LINET's Essenza 300 bed, using a female volunteer who weighed 50kg and was in a supine position. For the testing, the compressor was set to the shortest alternating cycle (HybriMatt family: 10 minutes, Air2Care family: 10 minutes and Virtuoso family: 7.5 minutes), and the pressure in the mattress was adjusted according to the weight of the volunteer (Level 1 on all type of mattresses). Average pressure and contact area were analyzed in 8 or 9 cells located under volunteer torso. These data were measured for different phases of alternation (A, B, and optionally C phases). Additionally, the differences in these values between phases of alternation were calculated to provide an overall comparison between different designs of alternating mattresses. A higher difference in pressure and contact area between phases indicates a greater offloading of the volunteer's body, which can be translated as the effectiveness of the alternating cells.

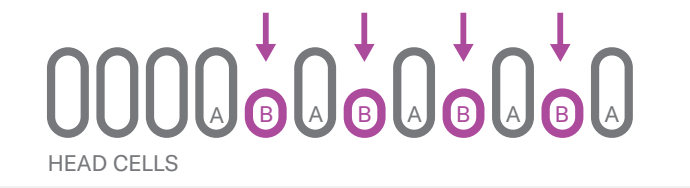
WHAT IS A, B, AND OPTIONALLY C PHASE OF ALTERNATING CYCLE?

2-CELL ALTERNATING CYCLE

PHASE "A"



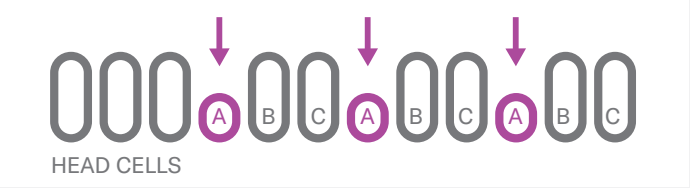
PHASE "B"



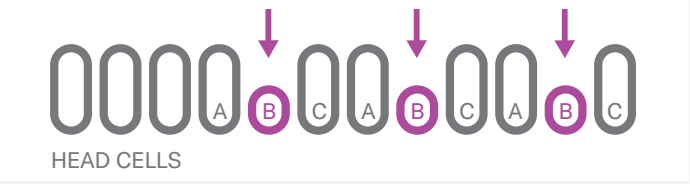
In 2-cell alternating mattresses, during the first half of the alternating cycle, A cells are deflated, and B cells are inflated (Phase A). In the second half, the cells switch, with A cells inflated and B cells deflated (Phase B).

3-CELL ALTERNATING CYCLE

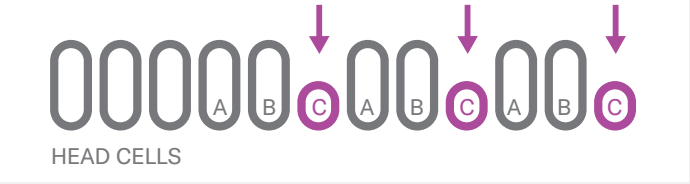
PHASE "A"



PHASE "B"



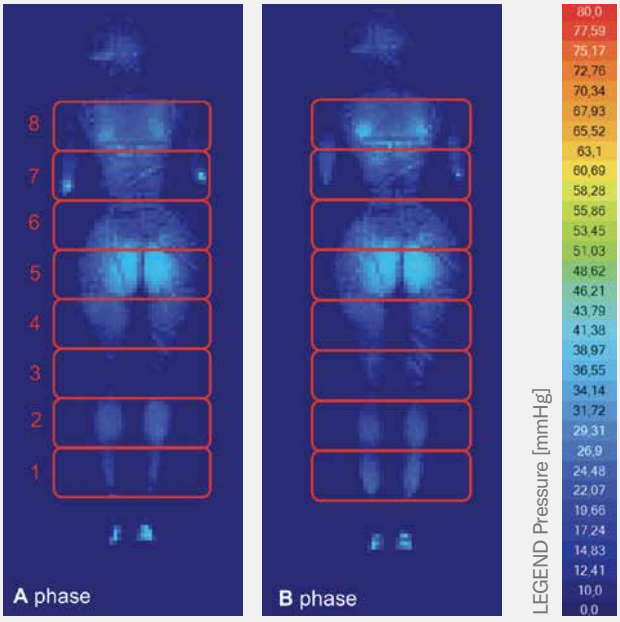
PHASE "C"



In 3-cell alternating mattresses, there are three phases. During the first third of the cycle, A cell is deflated while B and C cells are inflated (Phase A). In the second third of the cycle, cell B is deflated while cell A and C cells are inflated (Phase B). In the last third of the cycle, C cells are deflated while A and B cells are inflated (Phase C).

RESULTS OF PRESSURE MAPPING OF EACH ALTERNATING SUPPORT SURFACE IN LINET PORTFOLIO

HYBRIMATT FAMILY SOLUTION



Summary

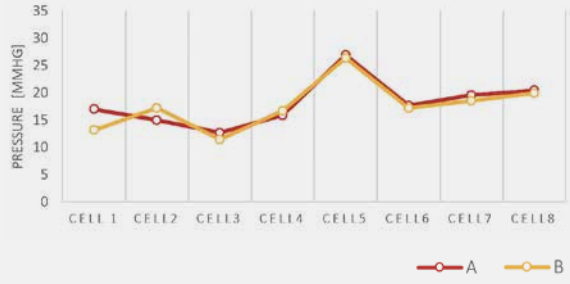
The design of the HybriMatt mattress incorporates layers of different foams to provide pressure redistribution in passive mode and active 2-cell alternation when connected to a compressor.

The HybriMatt mattress features polyurethane foam cores with alternating cells, topped with a compact layer of viscoelastic "memory" foam.

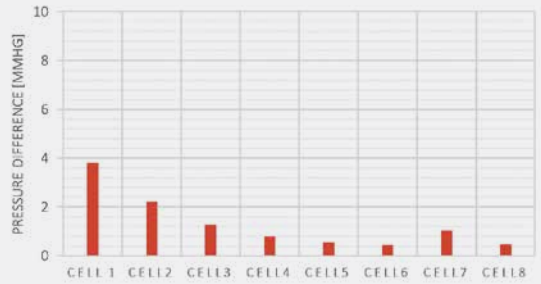
Results from pressure mapping demonstrate that cycle alternation creates changes in pressure and contact area across the cells. These values depend on the amount of load applied to specific cells. The highest load and contact area are on cell five, where the volunteer's pelvis is positioned. This indicates that the alternation effect is smallest in this cell.

On average, the change in pressure is 1.3 mmHg, and the change in contact area is 5.6 %.

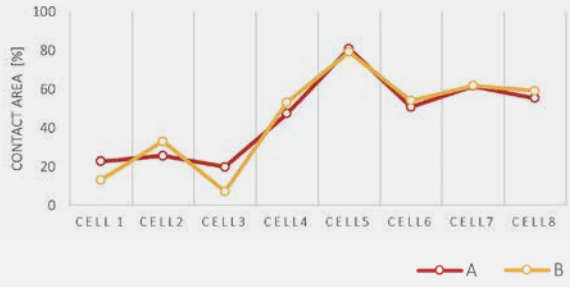
GRAPH 1 | Average pressure between A and B phase



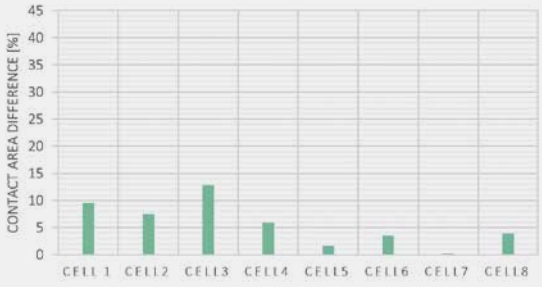
GRAPH 2 | Average pressure between A and B cell



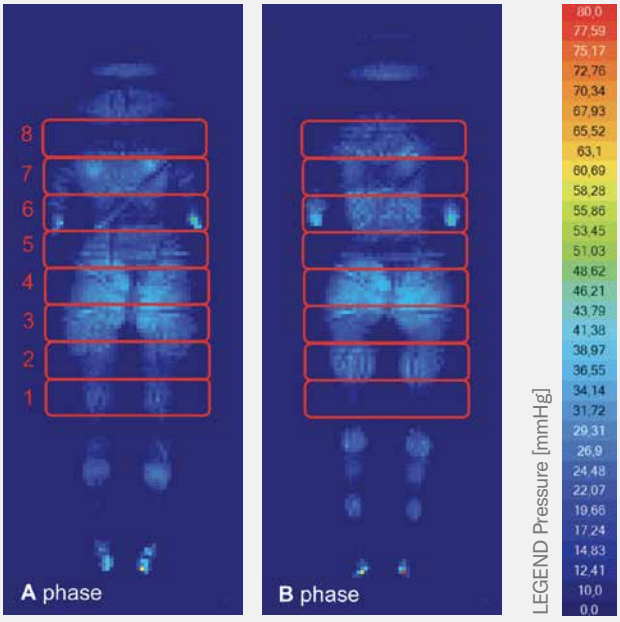
GRAPH 3 | % Contact area between A and B phase



GRAPH 4 | % Contact area difference between A and B cell



AIR2CARE 5 OVERLAY



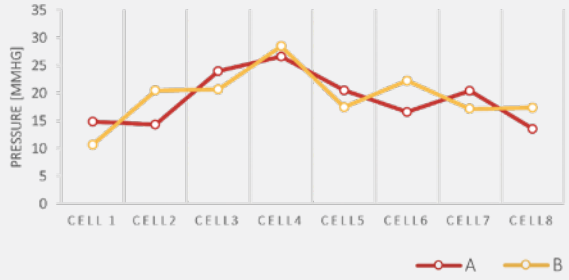
Summary

The design of the Air2Care 5 overlay consists of a single layer of 2-cell alternating air cells across its length. This pressure air overlay needs to be placed over the mattress. In this case, a MediMatt 30 mattress, made of polyurethane and cold foam layers, was used.

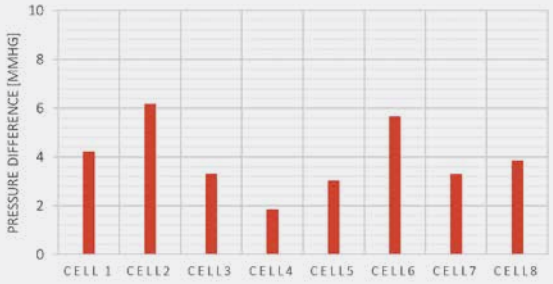
Graphs of average pressure and contact area demonstrate how the phases of the alternation cycle impact pressure and contact area and they change across all cells. The effectiveness of alternation depends on the load applied. The lowest change in pressure and contact area occurred in cell four, where the pelvis is located, which is also visible in the pressure map images.

On average, the change in pressure is 3.9 mmHg, and the change in contact area is 16.5 %.

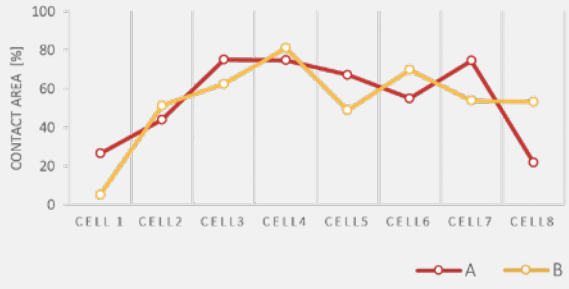
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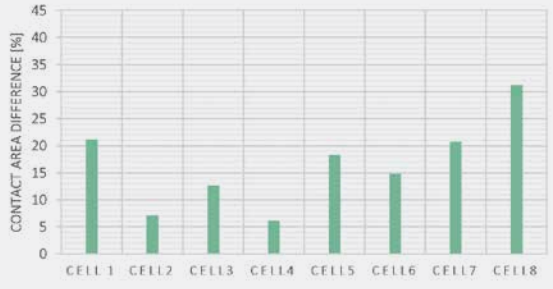
GRAPH 2 | Average pressure between A and B cell



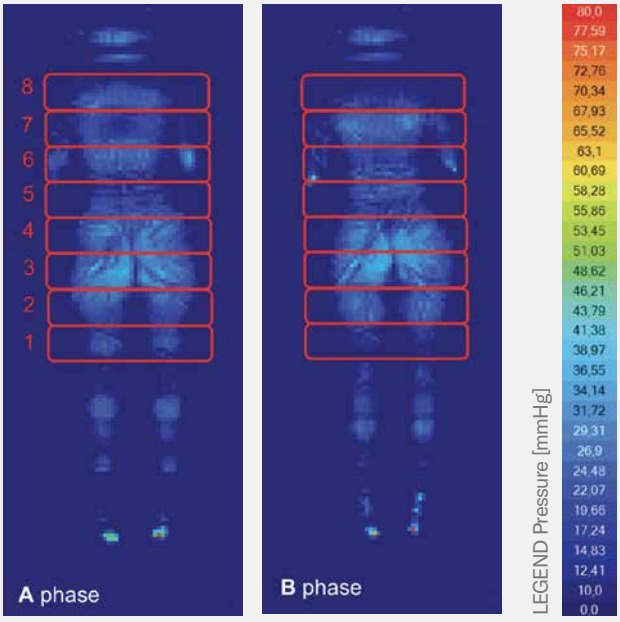
GRAPH 3 | % Contact area between A and B phase



GRAPH 4 | % Contact area difference between A and B cell



AIR2CARE 6 AND 8 (IN) MATTRESSES



Summary

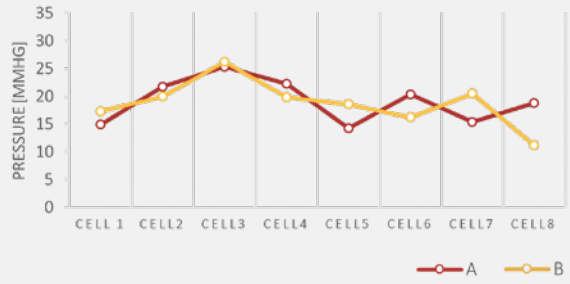
Air2Care mattresses are pressure air mattresses available as either mattress replacements or integrated mattresses. The main differences between the 6 and 8 options are the height of the mattress, which affects the maximum patient weight that can be supported.

The mattress is designed with long cells divided by chambers, and to protect the patient from bottoming out, only the top chambers alternate. The compressor must always be connected.

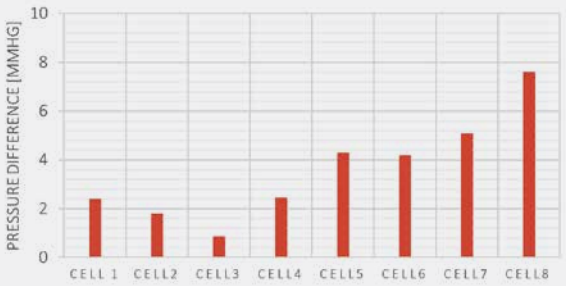
Graphs of average pressure and contact area show that pressure and area change, but in the pelvic region over cells 3 and 4, the change is smallest.

On average, the change in pressure is 3.6 mmHg, and the change in contact area is 8.3%.

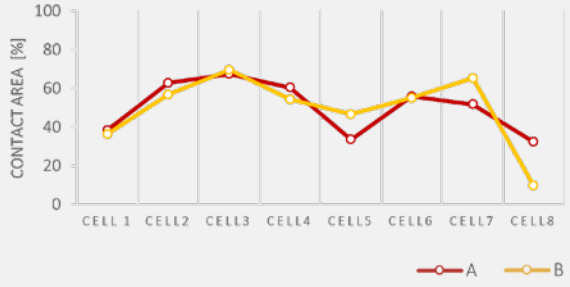
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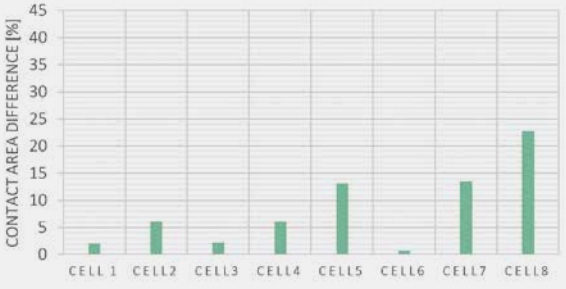
GRAPH 2 | Difference of avg. pressure between A and B cell



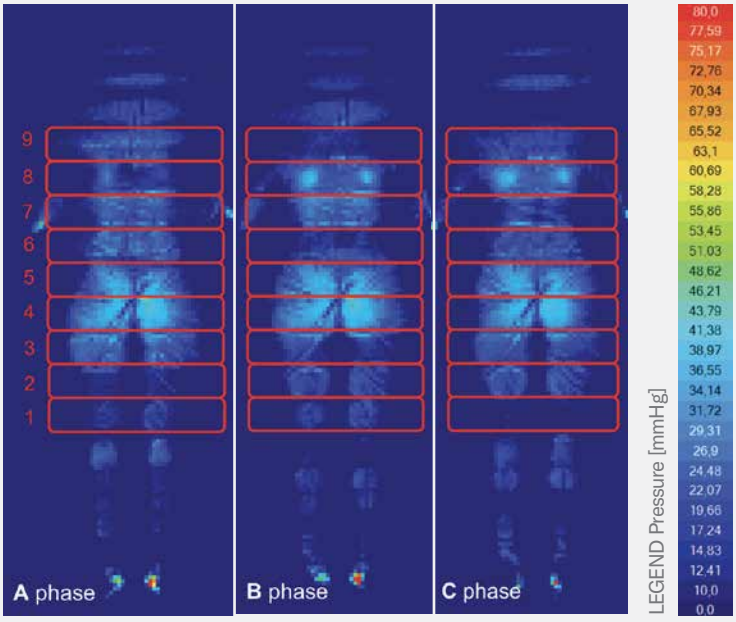
GRAPH 3 | % Contact area between A and B phase



GRAPH 4 | Difference of % contact areas between A and B cell



VIRTUOSO OVERLAY



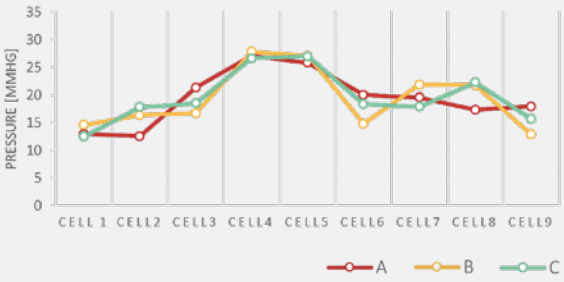
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The design of the Virtuoso overlay consists of a single layer of 3-cell alternating air cells across its length. This pressure air overlay needs to be placed over the mattress. In this case, a MediMatt 30 mattress, made of polyurethane and cold foam layers, was used.

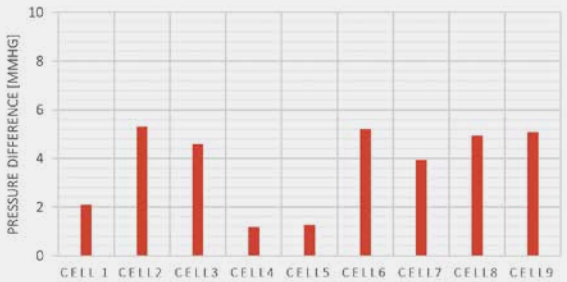
Graphs of average pressure and contact area demonstrate how the phases of the alternation cycle impact pressure and contact area. The higher effect of alternation is visible in change of contact area. The effectiveness of alternation depends on the load applied. The lowest change in pressure and contact area occurred in cells 4 and 5, where the pelvis is located.

On average, the change in pressure is 3.7 mmHg, and the change in contact area is 17 %.

GRAPH 1 | Average pressure between A, B and C phase



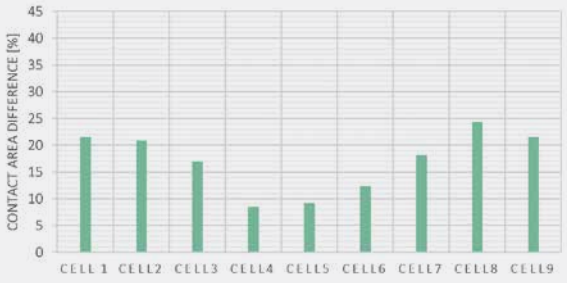
GRAPH 2 | Max. difference of avg. pressure between A, B and C phase



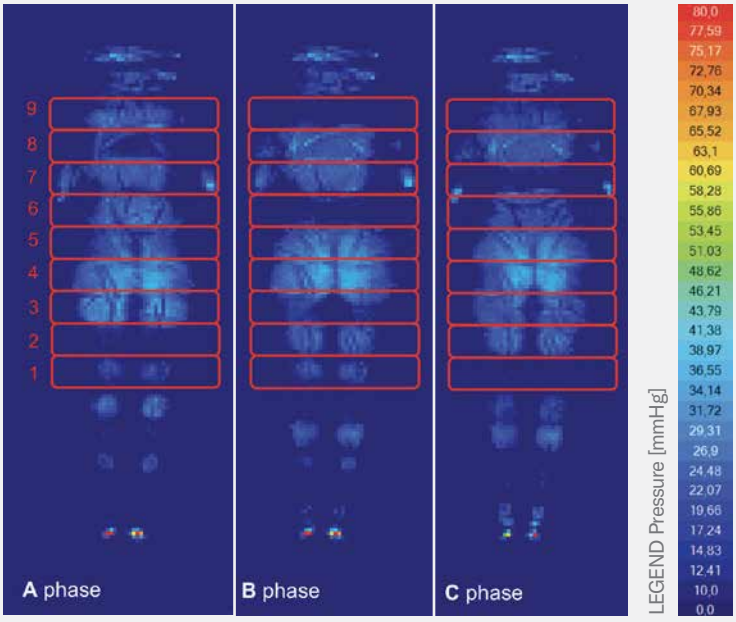
GRAPH 3 | % Contact area between A, B and C phase



GRAPH 4 | Max. difference of % contact areas between A, B and C phase



VIRTUOSO 100 MATTRESS REPLACEMENT



Summary

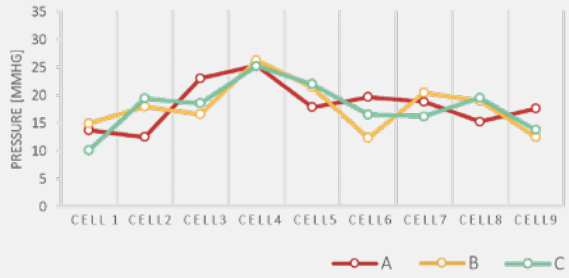
Virtuoso 100 is a 3-cell alternating pressure air mattress, which consists of two layers. The bottom layer is filled with static air, and the top layer fully alternates.

The graphs of average pressure and contact area clearly demonstrate the effect of alternation.

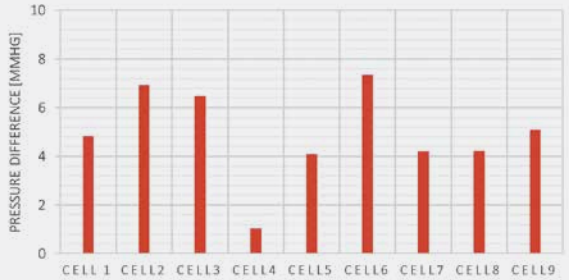
Pressure and contact area change across all cells, with some parts of the body being fully offloaded (empty areas on the pressure map). However, in the pelvic area, offloading was smaller in cells 4 and 5 compared to other cells, but the offloading is still noticeable.

On average, the change in pressure is 4.9 mmHg, and the change in contact area is 25.5 %.

GRAPH 1 | Average pressure between A, B and C phase



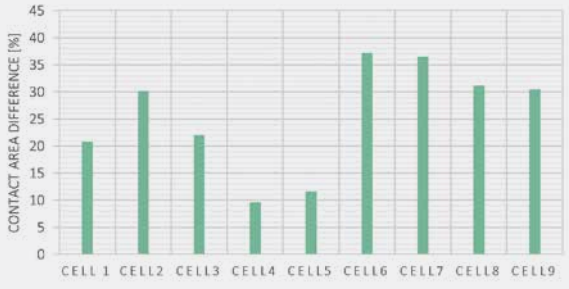
GRAPH 2 | Max. difference of avg. pressure between A, B and C phase



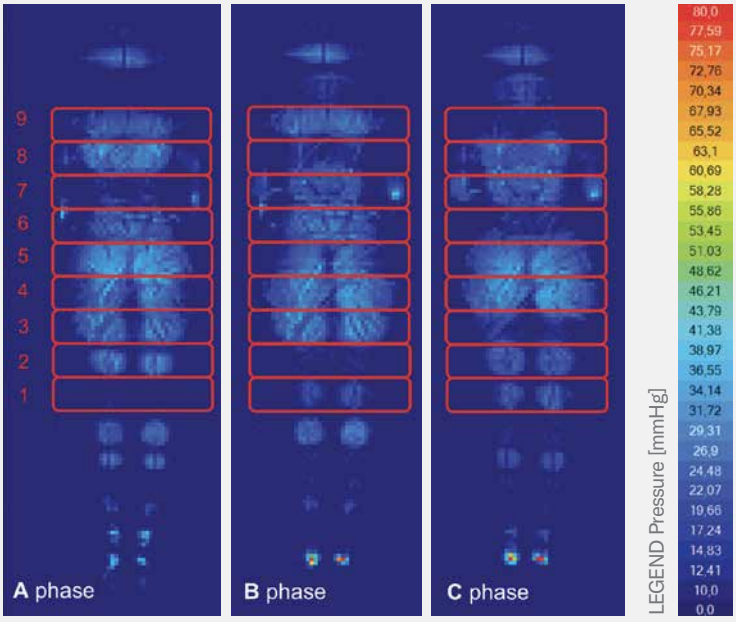
GRAPH 3 | % Contact area between A, B and C phase



GRAPH 4 | Max. difference of % contact areas between A, B and C phase



VIRTUOSO 200, 300 AND PRO MATTRESS REPLACEMENT



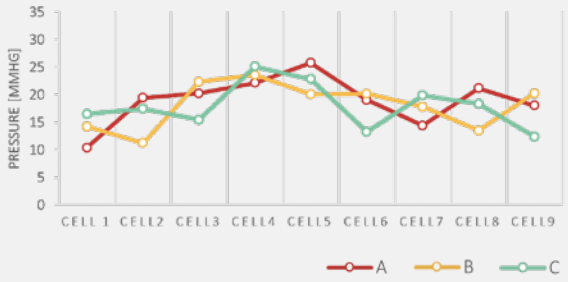
Summary

The Virtuoso 200, 300, and PRO are 3-cell alternating pressure air mattresses designed with two layers of air cells, each alternating. The main difference between versions lies in the ability to deflate individual cells and stop them from alternating. The Virtuoso 300 offers the option to deflate cells in the head and heel zones, while the Virtuoso PRO allows deflating any cell, such as for the proning position of a patient.

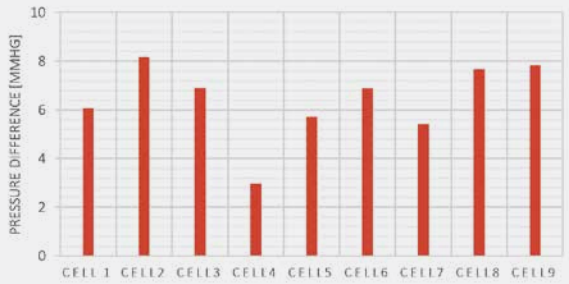
Fully deflating cells in both layers increases the effect of offloading on the volunteer's torso. A graph demonstrates that offloading results in a clear reduction of average pressure and contact area, even in cells under higher load due to the pelvis.

On average, the pressure change is 6.4 mmHg, and the change in contact area is 24.8%.

GRAPH 1 | Average pressure between A, B and C phase



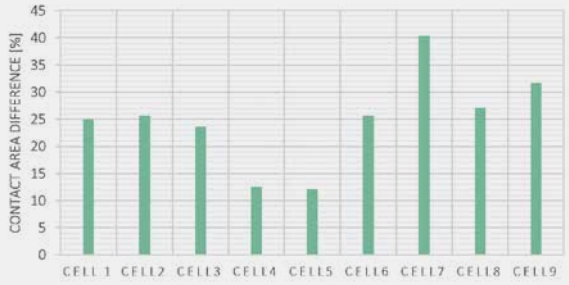
GRAPH 2 | Max. difference of avg. pressure between A, B and C phase



GRAPH 3 | % Contact area between A, B and C phase



GRAPH 4 | Max. difference of % contact areas between A, B and C phase



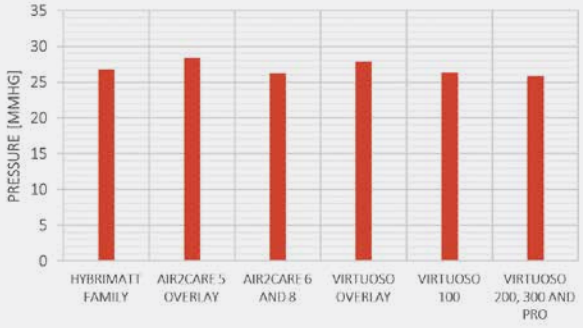
DISCUSSION OF PRESSURE MAPPING RESULTS FOR ALTERNATING MATTRESSES IN THE LINET MATTRESS PORTFOLIO

Based on pressure mapping of different designs of LINET alternating mattresses and overlays, noticeable differences in the effectiveness of alternating designs can be observed. As mentioned earlier, effectiveness of alternation is defined by differences in average pressure values and contact area for each cell.

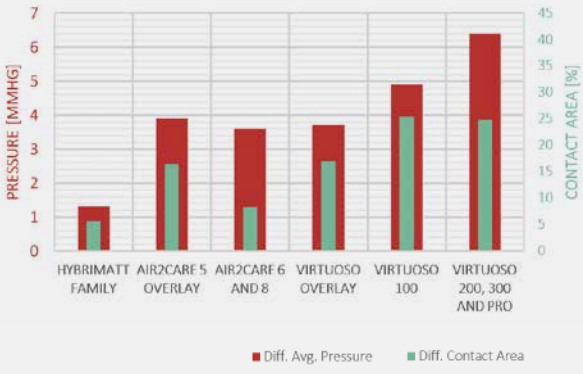
All LINET alternating support surfaces achieved average pressures under 30 mmHg, with the largest difference being 2.5 mmHg between the Air2Care 5 overlay and the Virtuoso 200, 300, and PRO models.

While average pressures across mattresses are similar, design diversification is evident in the differences between alternation phases. The Virtuoso 3-cell alternation achieved the highest offloading of pressure and contact area. That is visible in numbers, when comparing the difference results of Virtuoso 200, 300, and Pro with Air2Care 6 and 8, which represent fully alternating mattress replacements, the Virtuoso system offers 44% more pressure relief compared to the Air2Care. The 3-cell design allows for complete deflation of cells because the patient is always supported by inflated cells covering 66% of the body area. In contrast, the 2-cell alternation design achieves slightly less effective alternation because part of the cell must remain inflated to prevent bottoming out, with only 50% of the patient's body supported by inflated cells.

GRAPH 1 | Average pressure in analyzed cells



GRAPH 2 | Average differences between alternation phases



In terms of results for contact area, the Air2Care overlay compared to Air2Care 6 and 8 exhibits higher differences between phases. This difference may be attributed to the ability of the overlay to completely deflate cells compared to the mattress, which always provides protection against bottoming out. It should be noted that testing was conducted using a new mattress, MediMatt 30, and results for overlays may be affected if used over a worn-out mattress. In contrast, Air2Care 6 and 8 is mattress replacement, and compared to overlay is not placed on foam mattress.

The HybriMatt family shows the smallest differences between alternating phases in terms of pressure and contact area across all designs. This is due to the mattress design, unique for hybrids, which can be used as passive or active system. The cell design, featuring wider cells with a foam core, means they cannot deflate in the same manner as cells of pressure air mattresses. However, this design allows for versatility as the mattress can be used without a compressor. Unlike pressure air mattresses, HybriMatt family enables rapid response to patient conditions without needing to change mattress or add overlay, thus avoiding the need for patient transfer.

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