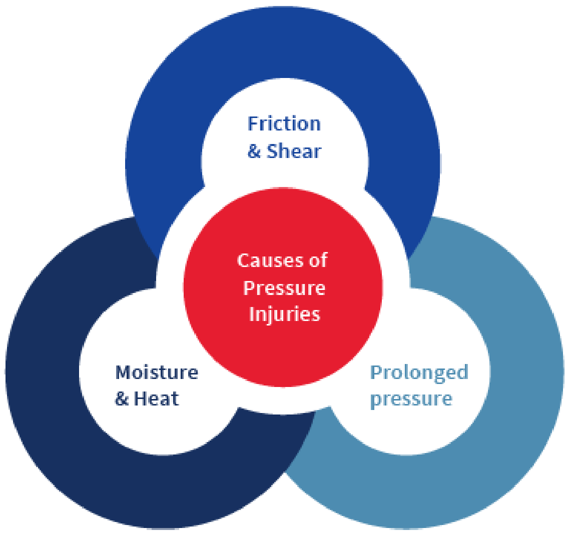
Prone Position

Risk factors and development of pressure injuries

Pressure Injuries commonly occur as a result of tissue being exposed to prolonged pressure or pressure associated with friction & shear, or the weaker tissue caused by moisture.

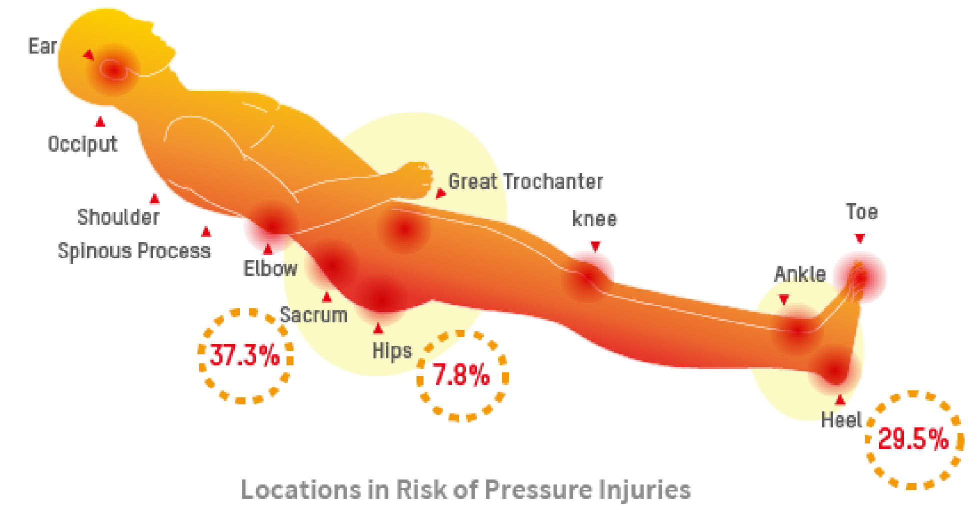


Common Risk Factors of Pressure Injuries

Pressure injuries are categorized into 6 stages: Stage I with a non-blanchable erythema of intact skin; Stage II with a partial-thickness skin loss with exposed dermis; Stage III with a full-thickness skin loss; Stage IV with a full-thickness skin and tissue loss; Unstageable pressure injury is defined as obscured full thickness skin and tissue loss; And last, Deep tissue pressure injury is the persistent non-blanchable deep red, maroon or purple discoloration of the skin.

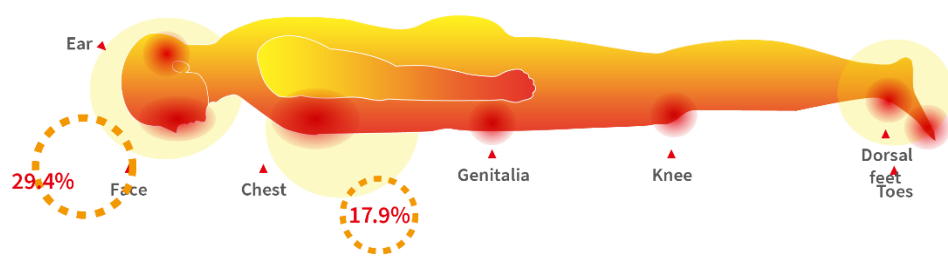
Stage 1	Stage 2	Stage 3	Stage 4	Unstageable Pressure Injury	Deep Tissue Pressure Injury
– Skin intact – Non-blanchable erythema	– Partial loss of dermis – Shallow open ulcers	– Full thickness skin loss – Fat exposed	– Full thickness skin loss – Exposed bone, muscle or tendon	– Covered with slough or eschar – Depth undetermined	– Purplish skin discoloration – Potential for deeper tissue damage

They may be superficial injuries affecting the epidermis and dermis or they can extend into the subcutaneous tissues and involve muscle, tendon and bone. Pressure injuries typically occur over bony prominences with the lower trunk (sacrum, coccyx, trochanter and ischial tuberosity) and heels being the two most common anatomical locations.[3,4]



Locations in Risk of Pressure Injuries

The prone position is related to a higher frequency of pressure injuries when comparing with the supine position.[5] Locations like the face, ear, chest, genitalia, knees, dorsal feet and toes are at high risk when patients are positioned in the prone position.[5,6]



Locations in Risk of Pressure Injuries in the Prone Position

Localized areas of tissues that have prolonged pressure cause the occlusion of blood flow, preventing the supply of nutrients and oxygen to the tissue, resulting in ischaemia and re-perfusion injury, leading to cell obliteration and eventually tissue death.[7]

From the information of the mechanism of pressure injuries above, additional risk factors that have been correlated with are age of 70 years and older, current smoking history, dry skin, low body mass index, impaired mobility, altered mental status (i.e., confusion), diabetes mellitus, peripheral vascular disease, urinary and fecal incontinence, malnutrition, physical restraints, malignancy, history of pressure injuries, and human race.

Pressure injuries can develop within 2 to 6 hours. Therefore, the key to preventing pressure injuries is to accurately identify at-risk individuals quickly, so that preventive measures may be implemented.
A major method of redistributing pressure is the use of support surfaces. Many researches had been conducted on the effectiveness of the use of support surfaces in reducing the incidence of pressure injuries. The concept of pressure redistribution has been embraced by the NPIAP.

"Support surfaces are: "Specialized devices for pressure redistribution."[9]

"Support surfaces are specialized devices for pressure redistribution designed for management of tissue loads, microclimate, and/or other therapeutic functions (i.e., any mattress, integrated bed system, mattress replacement, overlay, or seat cushion, or seat cushion overlay)." In this context, pressure refers to the distribution of force on the individual's body surface that is in contact with the device.

Acute Respiratory Distress Syndrome (ARDS)

Acute respiratory distress syndrome is a type respiratory failure with mortality rates around 35% to 45% based on its severity. Based on the Berlin Definition, PaO /FiO ratio is an indicator of hypoxemia and used to classify ARDS into 3 categories by the severity of hypoxemia.

Definition & classification

PaO_2/FiO_2	201 – 300 mmHg	101 – 200 mmHg	≤ 100 mmHg
ARDS	Mild	Moderate	Severe
Mortality	27%	32%	45%

(PaO_2: arterial oxygen partial pressure; FiO_2: fractional inspired oxygen)

Mechanism

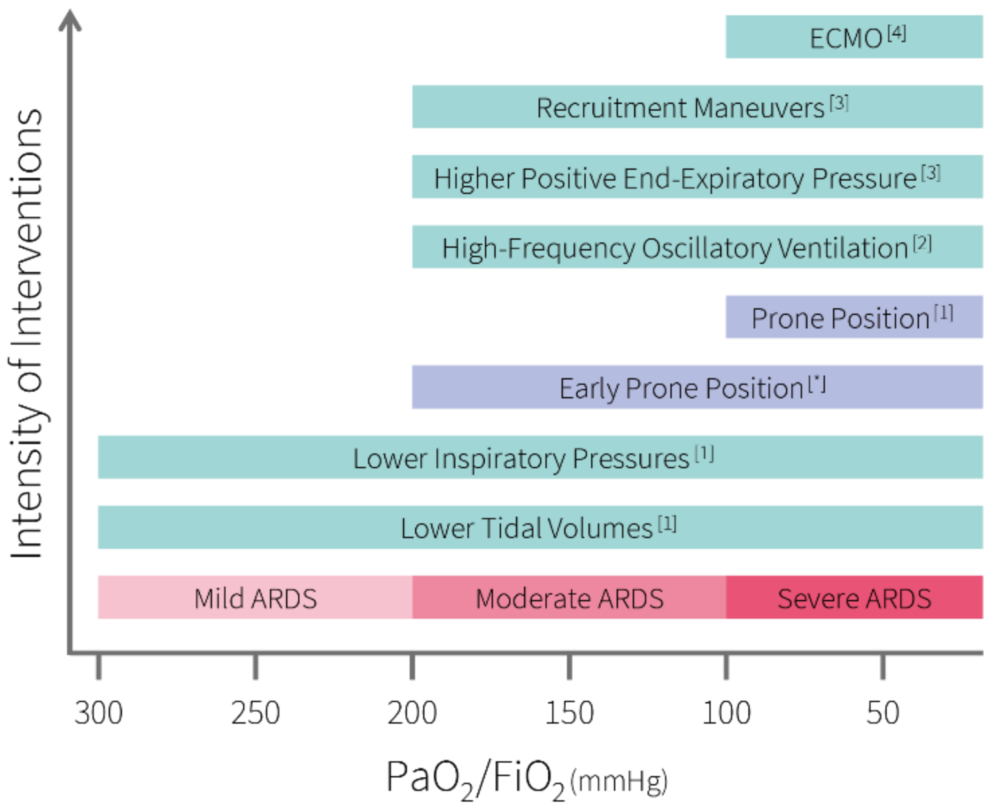
Injury to the lungs increases permeability of lung endothelium and results in oedema in the lung interstitium. Then, the breakdown of alveolar epithelium leads to translocation of fluids into the alveoli. The hallmark of ARDS is the accumulation of fluid, proteins, neutrophils and red blood cells in the alveolar space. Ventilation perfusion mismatch (V/Q mismatch) and pulmonary shunt are the major causes to hypoxemia.

Causes of ARDS

Bacterial, viral or fungal pneumonia, non-pulmonary sepsis, pulmonary aspiration, trauma such as penetrating or blunt injuries to the lungs and other serious illness are associated with the development of ARDS.

Mechanical ventilation with ARDS

According to the guideline on Mechanical Ventilation in Adult Patients with Acute Respiratory Distress Syndrome published by The American Thoracic Society (ATS), European Society of Intensive Care Medicine (ESICM) and Society of Critical Care Medicine (SCCM), we summarized the recommendation of different interventions based on their severity. Early prone position is also recommended in moderate or severe ARDS patients.



[1] Strong recommendation for the use of intervention
[2] Strong recommendation against the routinely use of intervention
[3] Conditional recommendation for the use of intervention
[4] Further evidence is needed before definitive recommendation for or against the use of intervention

Prone position ventilation

"Use a pressure redistribution support surface or positioning devices to off load pressure points on the face and body while in the prone position."

"Avoid extended use of prone positioning unless required for management of the individual's medical condition."

Prone positioning of patients was used in 16.3% (119 out of 729 patients) of patients with severe ARDS based on an international, multi-center, prospective cohort study. By positioning patients in the prone position will increase gas exchange and oxygenation. Patients' mortality rate was significantly lower in the prone position when comparing to the supine position. Prone positioning of patients may improve their survival rate but it may also increase the incidence of pressure injuries. Therefore, prevention of pressure injuries in susceptible areas is important.

		Supine	Prone
Blood Flow	Ventral lung	Minor	Minor
	Dorsal lung	Major	Major
Alveoli	Ventral lung	Overexpansion	Decreased overexpansion
	Dorsal lung	Collapsed	Decreased collapsed
V/Q		Mismatch	Better match

Table 1. Physiology differences of supine and prone position in acute respiratory distress syndrome

Supine position vs prone position in ARDS patients[23]

Ventilation perfusion mismatch or V/Q mismatch is seen in patient lying in supine position, meaning one or more areas of the lung receive blood flow but no oxygen or they receive oxygen but lack blood flow. Placing patient in prone position can change the mechanics and physiology of gas exchange to improved oxygenation (Table 1, Table 2).

Contraindications to prone position ventilation

Spinal instability, open chest post cardiac surgery/trauma, unstable fractures especially facial or pelvic, anterior burns, pregnancy, conditions associated with raised intracranial pressure, etc.

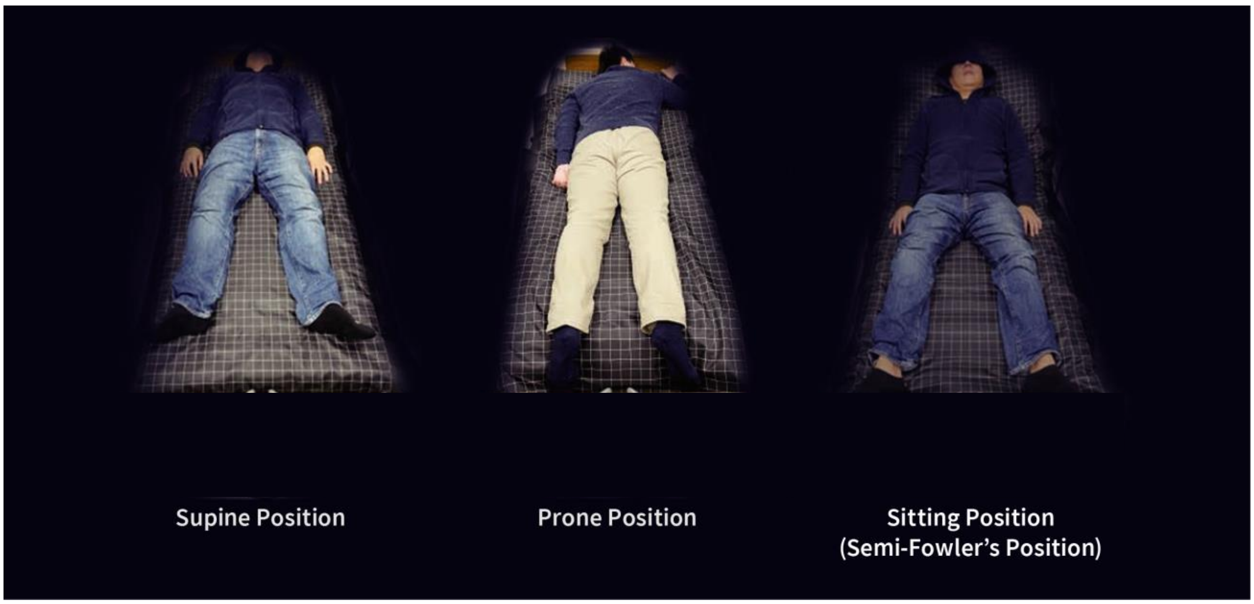
Prone position guidance

Guidance for: Prone Positioning in Adult Critical Care, published by The Intensive Care Society and the Faculty of Intensive Care Medicine (FICM), provides an example of safe and effective practice. For detail instructions, please refer to the original publication.

	Supine position	Prone position
Alveolar expansion	The nondependent alveoli (ventral alveoli) are more distended than the dependent alveoli (dorsal alveoli). This is likely exaggerated especially in ARDS patients when placed in the supine position due to increase of lung weight.	In the prone position, not only can it lower overexpansion of the ventral alveoli but also decrease collapse of the dorsal alveoli.
Lung compression	In the supine position, the heart and the diaphragm compress the lungs and lead to collapse of the dependent lung.	The heart lies on the sternum and the diaphragm is displaced caudally. Compression of the lung is decreased.
Lung perfusion	Collapse of alveoli and blood flow are at most in the dependent region of lung causing a ventilation perfusion mismatch (V/Q mismatch) phenomenon.	Ventilation perfusion match is better since the alveoli in the former dependent region of the lung begin to expand and still receive the greater part of the blood flow. On the other hand, the alveoli in the newly dependent region of the lung start to collapse while receiving the less part of the blood flow.

Table 2. Physiologic effects on oxygenation

Methodology: Each test is conducted over a 60-minute period during which the average, peak and minimum pressures are recorded.



*No. 9 & 11 cells were deflated in the torso section and No. 20 ~ 21 cells for the lower leg section when testing in prone position. For more information, please refer to the Individual Air Cell Deflation section.

Pressure Area Index (PAI): Pressure Area Index (PAI) is a method used to measure the interface pressure of the surface. The PAI is calculated as the proportion of sensors that register interface pressure values.

Pressure Redistribution Index (PRI): Pressure Redistribution Index (PRI) is a method to assess the ability of a dynamic support surface to sustain interface pressures below a chosen set of thresholds. The PRI is calculated as the ratio of the time during which the dynamic support surface interface pressure trace spends below the threshold and the total time of one inflation/deflation cycle.

Product Therapy Modes and Performance

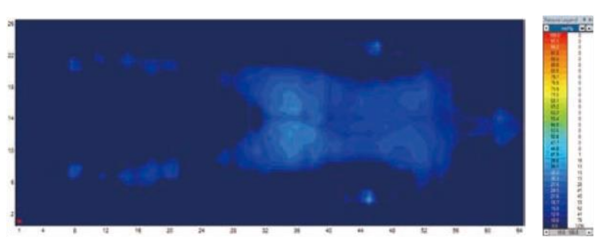
Initial inflation

Once the pump recognizes the mattress size through the quick connector, it will begin to inflate mattress which takes less than 30 minutes to complete the initial inflation.

Continuous low pressure (CLP)

"Consider using a reactive air mattress or overlay for individuals at risk for developing pressure injuries."[28]

Reactive air mattresses redistribute pressure by deforming in response to an individual's weight on the surface. Flex Wave offers a Continuous Low Pressure mode, which provides a stable surface with a pressure lower than the corresponding level when in the alternating mode. Also, this therapy mode is for the patients who are not fond of vibrations or alternating sensations.



SupinePosition:PAI & Pressure Mapping test of Flex wave in the supine position for 30 min. User height 177 cm, user weight 90 kg, and BMI 28.73.

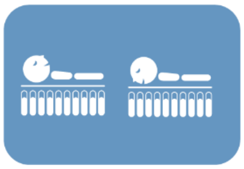
CPR Operation

CPR strap is located at the patient's left-hand side of the mattress near the head section area. Whenever a CPR operation is needed, quickly turn the CPR strap to release air from the mattress. The CPR deflation time is within 15 seconds. The quick connector on the pump unit can be disconnected for an even faster deflation process.

Design of mattress

Supine position mode & prone position mode

Replacement PAC offers two modes for different positions: Supine Position Mode & Prone Position Mode. Before turning the patient, select a mode and Max Firm will be activated automatically to provide a stable surface for turning pro cedures which last for 20 minutes.



Prone position timer

Prone ventilation for 12–16 hours per day is recommended in patients with severe ARDS. Once you selected the Prone Position Mode, it will start the timer automatically to show caregivers how long the patient have been positioned in prone position.

Individual air cell deflation

One-handed control knobs (which have been designed for helping prevention of cross infection) along the side of the mattress allow individual cells to be deflated. The only exception is the 4th air cell which aims to support the shoulders.

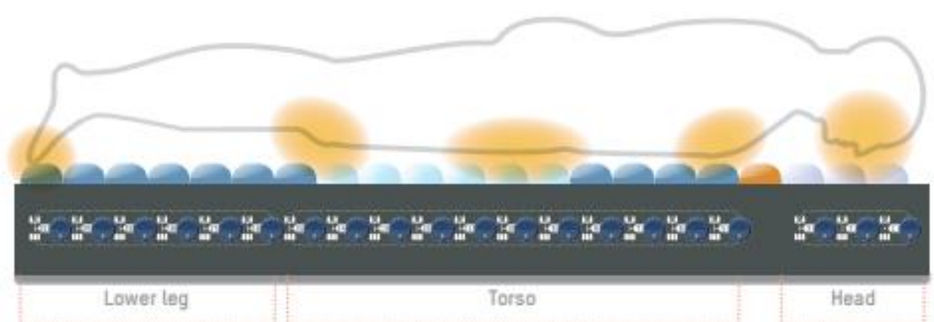
The knobs are numbered from 1 to 21 and are split into 3 sections: Head, Torso and Lower leg.

Completely deflate cells according to patient's vulnerable areas either in the supine or the prone position.

Based on these areas, we recommend you deflate:

- 2 cells in the Torso section (No. 5 – 15), 1 at the abdomen to increase ventilation or 1 at the chest to reduce pressure and 1 at the groin to ensure no compression to the urinary catheter.
- 1 cell in the Lower leg section (No. 16 – 21) to achieve zero pressure to the heels (supine position) or dorsal feet and toes (prone position).
- 1 cell in the Head section (No. 1 – 3) when the patient is placed in the supine position or 3 cells in the Head section when repositioning the patient's head in the prone position.

Aside from the therapy needed, we highly recommended not to deflate any more cells we mentioned above to ensure the support of the patient.



Heel relief function

"The heel is one of the two most common anatomical sites for pressure injuries. In a European survey on pressure injury prevalence, almost 80% of all Category/Stage IV pressure injuries were found at the sacrum and heels."[33]

Pressure redistribution in the head section

"Use a pressure redistribution support surface or positioning devices to offload pressure points on the face and body while in the prone position… Individuals placed in the prone position may be at increased risk for the development of facial pressure injuries."[19]

Head section of RPAC provides gentle support of the head. Alternating mode, the 3 head section cells along with the rest of the cells alternate to provide pressure relief of the head in prone position and also protect the occiput, which is also susceptible to pressure injuries in the supine position. A special foam design helps prevent pressure injury to the patient's ears by achieving zero pressure to the ear when being positioned in swimmer's position. This design is based on the CAESAR database for human ear size.