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A REVIEW OF MEDICAL DEVICES-RELATED PRESSURE ULCERS

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ABSTRACT

Medical device-related pressure ulcers (MDRPUs) is skin breakdown related to certain medical devices which may be used for either therapeutic or monitoring reasons such as; respiratory equipment, intravenous access, feeding tubes, and fixation devices, approximately one third of the reported pressure ulcers were associated with medical devices. Patients had a medical device were (2.4) times more likely to develop a pressure ulcer of any kind. (MDRPUs) is increasing source of patients' suffering and pain in addition to financial burden, and length of stay, furthermore (MDRPUs) were more likely than non-device-related pressure ulcers to be located on the head, face, or neck that cause stigma for the patients due to body image disturbance that affects coping. There are several contributing factors may be helped to occur this clinical problem which divided into; intrinsic and extrinsic factors. Since the (MDRPUs) are an easy to prevent but difficult to cure, almost of recent studies concerned with prevention strategies. The current review considered the latest evidenced information from different valid sources and attempt to explore and comprehensively highlight the (MDRPUs) as a clinical challenge covering the incidence, patients & institutional burden, contributing factors, tools of assessment, give a prospective window on the preventive strategies, and generate an attention and motivation for further researches in this area.

Key words: Medical Devices, Pressure Ulcer, Incidence, Prevention, Review.

INTRODUCTION

The skin is one of the largest organs in the body in surface area and weight. The skin has three main functions: protection, regulation and sensation. Pressure ulcers defined as localized injuries to the skin and/or underlying tissue as a result of continuous pressure. Pressure sores, decubitus ulcers and bedsores; are synonyms for pressure ulcers [1]. Pressure ulcers recently were classified into; device-related pressure ulcers and non-device-related pressure ulcer. Medical device related pressure ulcers (MDRPUs) are specifically defined as skin breakdown related to certain medical devices used for diagnosis of management. Researches evidenced that, nearly a third of the reported pressure ulcers were associated with the use of medical devices [2]. Pressure ulcers related to the use of medical devices are areas of localized injury to the skin or underlying tissue as a result of sustained pressure from a device.

The soft tissue injury usually mimics the shape of the device, which is often rigid or secured with tight dressings. These Pressure ulcers can evolve into full-thickness pressure ulcers due to the lack of adipose tissue in many of the areas of ulceration [3].

Patients may be particularly vulnerable to (MDRPUs) for a number of reasons, such as; malnutrition, hypotension, hypoalbuminemia, decreased mobility and inhibition of sensory perception as a result of sedating medications, neurologic disease/injury and severe neuropathy that prevent awareness of pressure and movement in response to tissue ischemia. [4-5]. It's worthy to mention that medical device itself creates pressure, humidity, and heat to the skin changing the microclimate of the skin. Often these devices must be secured tightly to assure a proper seal which, in turn, creates pressure in unusual areas rather than the bony prominences. The materials used to secure the device (e.g. tape, straps) may make it difficult to inspect the underlying skin beneath them. All of these factors increase the risk of pressure ulcers [6]. General factors contributing to (MDRPUs) include edema and moisture. The presence of edema at the site of the device can lead to increased pressure and tension under the device, excess moisture from human fluids around the insertion site can weaken the skin through maceration and alter the acid mantle of the skin. Friction from the constant rubbing of a tube or stabilizing device also can be a contributing factor [7].

Although researches on pressure ulcers as a result of medical devices are scant, in fact nearly a third of the reported pressure ulcers were associated with the use of medical devices such as respiratory equipment and tubing. Also if patients had a medical device, they were (2.4) times more likely to develop a pressure ulcer of any kind [8-9]. Actually most of nursing activities and protocols of care concerned mainly with preventing and treating pressure ulcer which is caused by continuous bony prominence pressure and pay no attention to prevent the (MDRPUs) which arise mostly at the first few days of admission when all caring activities concerned with patient reason of admission [8-10].

PATIENTS AND INSTITUTIONAL BURDEN

Medical device related pressure ulcers (MDRPUs) are a prevalent problem that exists in various healthcare settings. They can lead to morbidity, mortality, lengthy hospital stays, higher costs of

treatment (the cost of treating (MDRPUs) in the USA is estimated to be $11.6 billion annually) [11] and negative impact on patients' quality of life [12]. In the United States (US), hospital-acquired pressure ulcers (HAPUs) are no longer paid for under the Medicare government health subsidies scheme [13].Intensive care units (ICUs) are reported to be among the hospital settings with the highest (MDRPUs) prevalence rates [14-15]. since critically ill patients are likely to suffer from several morbidities that increase the risk of (MDRPUs) development.

As (MDRPUs) are considered to be an avoidable problem and sensitive indicator of quality nursing care, nurses have a major role keeping the skin intact and preventing them from developing pressure ulcer [13-16]. Pressure ulcers have been recognized as a disease entity since ages. Pressure sores have been found in Egyptian mummies, some of which are more than 5,000 years old. During the renaissance, Ambrose Paré, a 16th century French army barber-surgeon and founding father of medical surgical practice, wrote in his autobiography about a wounded French aristocrat developing a pressure ulcer. In the 19th century, Jean-Martin Charcot studied decubitus ulcers and subscribed to the "neurotrophic theory" for the causation of ulcer rather than the "pressure" as we believe today[17].

INCIDENCE

There are a large number of literatures focused on the prevention of laying pressure ulcers using specialist beds, mattresses, cushions and repositioning. This is because the majority of pressure ulcers occur over bony prominences, most typically on the sacrum and heels. However, very little of the literature or sets of guidance specifically identify the problem of pressure ulcers related to the use of medical devices, which are becoming increasingly prevalent (Table 1).

Table 1: Published frequency of medical device related pressure ulcers

Reference	Frequency of occurrence of (MDRPUs)
Davis, et al.[18]	33% up to 5 days &44% over 5 days
Apold, et al.[7]	29%
Black, et al.[8]	34.5%
Ayer, et al. [19]	44%

Medical devices usually are made of rigid materials such as plastic, rubber or silicone, which can cause rubbing or create pressure on the soft tissues such as; respiratory equipment, intravenous access, feeding tubes, and fixation devices, drainage tubes [20]. Research on pressure ulcers as a result of medical devices spicifically is scant.

(44%) of the patients connected to cervical collars developed pressure ulcers [18], the frequency rate of the pulse oximeter-induced pressure ulcer was (5%) [19]. Pressure ulcers from non-invasive positive pressure ventilation (NIPPV) masks have been reported12% [8].

Common medical devices that produce pressure ulcers.

In fact, Pressure ulcers do not develop only in areas with bony prominences; they can develop in any tissue under pressure, including pressure exerted by medical devices. (30 –70% of MDRPUs) were located in the head, neck, face, ear [2]. The common medical devices that stated as a contributing of (MDRPUs) were; cervical collars, endotracheal tubes, face masks for non-invasive positive pressure ventilation, faecal containment devices, nasal cannulas, pulse oximetry probes, radial artery catheters, sequential compression devices, anti-embolic stockings, splints and braces, and urinary catheters. Endotracheal (ET) and nasogastric (NG) tubes were considered as a major cause device-related ulcers [10].Also, (ETT) and (NG) tubes related pressure ulcers affecting directly patient's face patient's that can be very psychologically harmful (Coyer, 2014).

CONTRIBUTING FACTORS

Contributing factors can largely be divided into intrinsic and extrinsic influences on tissues. Intrinsic influences - the patient's general physical condition and an adequate supply of nutrients and oxygen determine the resilience of the tissues and their ability to recover from a pressure insult or injury. Extrinsic influences include pressure and shear, but also moisture at the skin surface, which will affect skin integrity [23]. The ability of a patient to mobilize, Activity or movement in bed is a strong predictor of risk people who move in sleep at least 20 times per night are less likely to suffer pressure injury than those who move less frequently. Numerous risk assessment tools have been developed since the 1960s to help nurses prevent pressure injuries. Most commonly used are the Braden, Waterlow and Norton scales. Scales such as these have both advantages and disadvantages. The precision of these scoring systems is important, as they are used to allocate limited resources (such as pressure-relieving devices and nursing time), support clinical decisions and assess quality of care [13]. However, many device related pressure ulcers occur because of poor positioning or fixation of the equipment [24]. Poor selection of equipment or simply because of a failure to check that the tubing

(e.g from a urinary catheter) is repositioned correctly when patients are moved [24-25-26].

Mechanism of medical device related pressure ulcers developing:

Medical Device related-pressure ulcer occurs where body tissues are compressed and/or exposed to shear sufficient by prescience and fixation of certain medical device to impair cell function. The greater the compression, the shorter the time required for injury to occur. Whether an ulcer develops depends on the duration and degree of pressure (or shear) and the resilience of the affected tissue. Damage from pressure and shear was believed to be due almost exclusively to compression of capillaries, causing loss of oxygen and nutrients to the tissues, in turn triggering cell ischaemia and necrosis. Tissue injury caused by pressure ulcer may be as a result of; Compression, ischemia, deformation, and reperfusion of subcutaneous tissue [21-22].

(A) **Compression:** Compression reduces blood supply to the cells, the region are forced to use anaerobic metabolism to maintain enough adenosine triphosphate (ATP) for cellular function [21]. (B) **Ischaemia:** Decreased supply of oxygenated blood (ischaemia), following compression of capillaries and occlusion of larger vessels due to shear, triggers anaerobic metabolism in affected cells. This, in turn, increases levels of lactic acid in the area, causing acidosis. Waste products accumulate, due to lack of venous and lymphatic drainage, causing oedema. Damage occurred to cell organelles and muscle fibers following as little as 90 minutes ischaemia in experimental studies. Prolonged ischaemia reduces (ATP) production and impairs cellular activity, eventually causing necrosis of the cells and formation of a pressure ulcer [22]. (C) **Reperfusion injury:** The restoration of blood supply (reperfusion) following a period of ischaemia is recognized in many conditions (eg stroke and myocardial infarction) as causing further damage to the affected tissues. The presence of lactic acid and accumulated waste products, as well as damaged cells, triggers reactive hyperaemia and inflammation as soon as the blood supply is restored. An influx of oxygen to the area causes generation of reactive oxygen (and nitrogen) species. These free radicals should be rapidly inactivated by antioxidants, but cells recovering from prolonged ischaemia cannot perform this function [21]. **(D) Deformation:** The third element in the

development of pressure sores is deformation of tissues and individual cells. Deformation of tissues impairs diffusion and lymphatic drainage, enhancing the development of local oedema. At the cellular level, compression causes the cell membrane to deform and malfunction it becomes more porous to calcium while lack of (ATP) means the influx of calcium cannot be corrected. Other transport mechanisms across the membrane are also affected. This places an osmotic stress on the cell and causes toxicity. Risk of damage increases with duration and degree of pressure but other factors affect the ability of the exposed tissues to survive compression and ischaemia [22].

TOOLS OF ASSESSMENT

Risk assessment

In the past, (MDRPUs) have been regarded as an inevitable outcome of severe illness or disability. In modern times, development of (MDRPUs) is regarded as a sign of neglect, particularly in relation to nursing care. While the majority of experts consider pressure injuries to be preventable, a small proportion may be unavoidable. Risk factors for development of pressure sores have been incorporated into assessment tools [23]. The highest risk is associated with immobility interfering with delivery of oxygen and nutrients to tissues, or that affect skin integrity, also play a significant role, consumer awareness and quality indicators have raised questions about the inevitability of these injuries [13].Assessing risk and implementing prevention measures require a good understanding of the underlying pathophysiological events in the development of pressure injuries. Rightly or wrongly, in modern health care, nurses are held directly responsible for their patients developing pressure ulcers. Managing risks and existing ulcersare typically a nursing responsibility. Expert care can reduce the impact on a patient's health, quality of life and risk of complications[13-27].

Risk factors assessed by the most common scores include, variously: mobility, activity, continence, mental state and neurological/sensory deficits, nutritional state, medications affecting tissue condition, and gender (now shown not to affect risk). Shortcomings in the commonly used risk assessment scales have been acknowledged in clinical guidelines. These suggest that scores be used in conjunction with expert clinical judgment. This, in turn, presupposes a level of expertise from the nurses performing the assessment. The easier path is getting nurses to rely on risk scales, rather

than educating them properly on how to use their clinical judgment to make the assessment. The tool becomes an end in itself, and factors unique to a patient, patient group or clinical setting, may be overlooked, especially by less experienced nurses[13].

The most preferred tool is the Braden scale for predicting pressure ulcer risk including medical device related. It consists of six categories: sensory perception, moisture, activity, mobility, nutrition, and friction/shear. The total score can range from 6 to 23 with a lower score indicating a higher risk. The level of risk indicates the intervention strategies that should be used [28].Low risk (Braden score 15 – 18), Moderate risk (Braden score 13 – 14), High risk (Braden score 10 – 12), Very high risk (Braden score = 9).

Assessment of Stages

According to the National Pressure Ulcer Advisory Panel's (NPUAP), 2015 Pressure Ulcer Staging System classified as the following; **Stage I:** Intact skin with non-blanchable redness of a localized area usually over a bony prominence. **Stage II:** Partial thickness loss of dermis presenting as a shallow open ulcer with a red pink wound bed, without slough may also present as an intact or open/ruptured serum-filled blister.**Stage III:** Full thickness tissue loss, subcutaneous fat may be visible but bone, tendon or muscle is not exposed. **Stage IV:** Full thickness tissue loss with exposed bone, tendon or muscle. Slough or eschar may be present on some parts of the wound bed. **Unstageable:** Full thickness tissue loss in which the base of the ulcer is covered by slough (yellow, tan, gray, green or brown) and/or eschar (tan, brown or black) in the wound bed.This staging system should be used only to describe pressure ulcers. Wounds from other causes, such as arterial, venous, diabetic foot, skin tears, tape burns, perineal dermatitis, maceration or denudement should not be staged using this system. Other staging systems exist for some of these conditions and should be used instead[2].

PREVENTIVE STRATEGIES

Nurses are the key members of the multidisciplinary teams and the primary advocates of supportive care for their patients especially when we talk about prevention of (MDRPUs). Nurses have a great opportunity to apply such evidence based guidelines to more effectively minimize the risk of (MDRPUs) [2-16].

Each of medical devices has unique aspects to the risks of ulceration and

prevention plans. Prevention plans must be comprehensive. Instituting measures to prevent harm from medical devices is paramount. Clinicians should be familiar with the medical devices that have been problematic in their health care system. Clinicians should be familiar with best practices that prevent (MDRPUs) for every medical device in use in their health care institution. Obese individuals are also at risk because tubes and medical devices can become compressed and hidden by large or deep skin folds. Any prevention plan must begin with obtaining the correct size of the medical devices. One-size-fits-all does not apply here[8].

The Prevention of Pressure Ulcers which was developed through a formal consensus process by the (NPUAP, 2015).(EPUAP, 2015), and Pan Pacific Pressure Injury Alliance [29]is considered the national standard for the prevention and treatment of (MDRPUs). The guideline includes 19 recommendations focused specifically on (MDRPUs), which cover how to assess patient risk, select and fit medical devices, assess the skin and the medical devices' effect on the skin, and ultimately prevent the occurrence of (MDRPUs). For each recommendation, the guideline provides both strengths of evidence (using grades A, B, or C) and strengths of recommendation. The strength of evidence grade is based on the level of supporting evidence (study design and quality).

Among the (MDRPUs) recommendations, a few overarching themes emerge, including;Consider all patients with a medical device to be at risk for (MDRPUs). Inspect the skin surrounding and under any medical device at least twice a day for signs of pressure related injury. Inspect the skin more than twice a day if the patient is at risk for fluid shifts or shows signs of localized or generalized edema.Remove potential device-related sources of pressure as soon as medically possible.Reposition the patient or device to redistribute pressure and reduce shear forces.

Moreover, (NPUAP, 2015), and (PPPIA2012) recommended the following instructionsfor preventing and reporting (MDRPUs).Determine that all medical devicesare commercially manufactured for use in the clinical setting (not homemade) and can be placed without making contact with prior or existing pressure injuries. Evaluate all devices, every skin–device interface, and the surrounding skin at least twice daily, and more often in patients with

localized or generalized edema. Verify that all nursing staff has been taught how to correctly use and secure medical devices and understand that mucosal medical device–related pressure injuries must be counted and tracked separately from skin pressure injuries. Identify all medical devices on all patients, especially those most vulnerable to medical device– related pressure injuries: critically ill patients, neonates, children, older adults, and bariatric patients. Educate all staff to look for objects that might be in the bed or chair under the patient. Consider the following any time medical devices are in use; - Does the patient still require use of the device can it be rotated, repositioned, replaced, or removed? - Is the fit correct? - Can a prophylactic dressing be used beneath devices placed in high-risk areas (the nasal bridge, for example)?

Apold, & Rydrych, 2014 stated nursing guidance for prevention of (MDRPUs) serve as an important source of information for identifying evidence based practices and effective strategies to minimize the risks of (MDRPUs) especially (ETT) and (NG) tube. The preventive actions should be aiming at: Minimize or eliminate friction and shear, Minimize pressure (off-loading), Support surfaces, Manage moisture, and Maintain adequate nutrition/hydration.Also, remove or move the device daily to assess the skin. And assess the following; Skin color, moistness, edema, integrity, and discharge. Document the findings of the skin assessment.Use a written repositioning schedule. Repositioning schedules should be individualized based on the patient's condition, care goals. Avoid placement of device(s) over sites of existing pressure ulceration. Keep the patient as active as possible; encourage mobilization. Do not massage or vigorously rub skin that is at risk of pressure ulcers. Keep the skin clean and dry. Provide hygienic care after nebulizer mask that causes excessive moisture. Offered a minimum of 30-35 kcal/kg/day. Give 1.25-1.5 g/kg/day of protein if there is no any restriction. Give 1 ml of fluid intake per kcal per day if there is no any restriction. Don't reuse the (NGT) or (ETT) again.

Expected barriers of implementing (MDRPUs) preventive measures

The prevention of (MDRPUs) is greater importance and cost beneficial than management. However, nurses at hospitals have given it low priority stemming from inadequate knowledge and heavy workload such as one nurse having many patients to attend to. The nurse training schools and universities need to examine their curricula

to address issues related to pressure ulcers prevention and treatment. Hospitals also need to devote more resources to prevent and manage pressure ulcers. Also, attitude of the nurses regarding implementing the (MDRPUs) preventive measures may be one of barriers. Authorities should also meet their responsibility to provide continuous nursing education (CNE) to staffs about pressure ulcers [3-30]

CONCLUSION

As (MDRPUs) are considered to be an avoidable problem and sensitive indicator of quality nursing care, nurses have a major role keeping the skin intact and preventing them from developing pressure ulcer. Medical devices usually are made of rigid materials such as plastic, rubber or silicone, which can cause rubbing or create pressure on the soft tissues (Jaul, 2010). In addition, adhesive tapes used to secure the device may irritate susceptible skin, especially if oedema then develops around the device. The insertion site of a device or the location of the device placement is most susceptible to tissue damage. Tissue damage may mimic the shape of the device and deteriorate rapidly, for example when located in an area where there is a lack of adipose tissue. To avoid pressure ulcers from occurring in any location of the body, it is important to inspect all external tubing and devices. It is therefore important to raise the level of awareness among staff on the correct placement and fixation of devices (Fletcher, 2012).

Preventing device related pressure ulcers is often much more complex than preventing pressure ulcers over the usual anatomical sites, such as the heels, sacrum or trochanter. This is because the device causing the damage often forms an essential part of the patient's treatment – for example, the use of a facemask in delivering non-invasive ventilation. In addition, there may be a number of predisposing factors such as incontinence, malnutrition and altered levels of consciousness or sensation. Several studies illustrated that the evidence based preventive interventios significantly minimized the occurrence and the frequency of (MDRPUs).

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