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Patient Handling Tasks with High Risk for Musculoskeletal Disorders in Critical Care

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Nursing remains one of the top 10 highest risk occupations in the United States for work-related musculoskeletal disorders (WMSDs) [1]. Compared with those in other occupations, nursing personnel are among the highest at risk. Nursing aides, orderlies, and attendants rank first and registered nurses sixth in a list of at-risk occupations for strains and sprains that includes truck drivers (first), laborers (third), stock handlers and baggers (seventh), and construction workers (eighth) [2]. Additional estimates for the year 2000 show that the incidence rate for back injuries involving lost workdays was 181.6 per 10,000 full-time workers in nursing homes and 90.1 per 10,000 full-time workers in hospitals, whereas incidence rates were 98.4 for truck drivers, 70.0 for construction workers, 56.3 for miners, and 47.1 for agriculture workers [3]. In 2001, for cases involving days away from work among registered nurses, 4547 were categorized as overexertion in lifting and 14,832 were listed as sprains or strains [4].

Work-related musculoskeletal disorders (WMSDs) in nursing persist as one of the leading and most costly occupational health problems in the United States. Nurses suffer a disproportionate amount of musculoskeletal disorders attributed to overexertion from lifting unsafe loads and to the potential cumulative effect of repeated patient handling tasks [5]. A variety of patient handling tasks exist within the context of providing nursing care, such as lifting, transferring, and repositioning patients. Continuous, repeated performance of these activities throughout a working lifetime without the use of mechanical assistive equipment results in the development or exacerbation of musculoskeletal disorders. Because patient handling tasks conventionally are performed manually without the use of assistive equipment, nurses are exposed to high levels of biomechanical loads on the spine. Although nurses historically have been educated and trained to use "proper" body mechanics and manual techniques to prevent injury from lifting and transferring patients, questions arise regarding the value of these methods and applicability to the practice of nursing [6,7].

The risk for development of WMSDs associated with manual patient handling crosses all specialty areas of nursing. No nurse effectively is free from the risk for injury. The purpose of this article is to describe high-risk patient handling tasks performed frequently in critical care units, delineate the physical demands associated with each task, identify technologic solutions, and outline useful tips for making each task safer.

Background

The Association of periOperative Registered Nurses (AORN) organized a task force that included representatives from AORN, the National Institute for Occupational Safety and Health (NIOSH), the Patient Safety Center of Inquiry at the James A. Haley Veterans Administration

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health or the Veterans Health Administration.

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Medical Center (VAMC) in Tampa, and the American Nurses Association to develop an ergonomic guideline for lifting and moving people and objects in perioperative work environments. The task force formulated clinical tools and algorithms for high-risk tasks in perioperative settings that incorporate current ergonomic safety concepts, scientific evidence, and available technology, including safe patient handling equipment and devices [8]. This article expands on the work done by the AORN for perioperative settings by applying the ergonomic principles proposed by AORN to nursing tasks in critical care settings.

Another ergonomic task force, led by the Patient Safety Center of Inquiry at the James A. Haley VAMC in Tampa, identified tasks associated with high risk for musculoskeletal disorders on five critical care units (two surgical ICUs, two medical ICUs, and one cardiac ICU) at two large medical centers to identify tasks with high risk for musculoskeletal disorders. The criteria used to identify potential high risk for WMSDs for critical care tasks included (1) high force, (2) awkward postures, or (3) repetitive loading. Data were collected through direct observation of physical work environment, technology, and work practices; digital photography; interviews with ICU nurses and nurse managers; and a 2-year review of WMSDs reported in ICUs. Based on this evaluation, seven high-risk patient handling tasks in critical care were identified as having high risk for musculoskeletal disorders. These include

1. Pushing occupied beds or stretchers
2. Lateral patient transfers (eg, bed to stretcher)
3. Moving patients to the head of a bed
4. Repositioning patients in bed (eg, side to side)
5. Making occupied beds
6. Applying antiembolism stockings
7. Lifting or moving heavy equipment

For each of these high-risk critical care nursing tasks, a brief description of the task is provided, the physical demands discussed, solutions proposed, and helpful tips for performing each task safely provided.

High-risk task #1: pushing occupied beds or stretchers

Description of the task

Critical care nurses identified "road trips" as one of the most physically demanding tasks performed. These trips involve pushing an occupied bed or stretcher off the unit for diagnostic testing, surgery, or other procedure. In addition to the weight of patients and beds or stretchers, these tasks are compounded by adding the weight of medical devices, such as intra-aortic balloon pumps, intravenous pumps, and portable ventilators. In addition, nurses may be expected to monitor patients while performing these tasks or manually ventilating patients while walking or pushing. Typically, these tasks require two or more persons for safety, and at least one person usually is walking backwards. The required force to push or pull an object is the same, but pushing is preferred over pulling because pulling often is done with one hand and with a twist of the trunk, resulting in unbalanced loads on the spine [9]. For this reason, pulling force limits for these tasks are not provided.

Physical demands

Factors that contribute to the physical demand of these tasks include distance traveled, weight being pushed, and uneven gradients (eg, slopes or thresholds). The wheels of beds and equipment get stuck in elevator and door thresholds. The potential physical risk factors associated with this task include excessive pushing or pulling and lifting demands. The likely result of excessive pushing, pulling, or lifting forces generated during this task is high-resultant spinal anterior-posterior shear and compression forces that likely exceed the recommended spinal tissue load tolerance limits. These limits are proposed as 3400 N (770 lb) for spinal disc compression force [10,11] and 1000 N (225 lb) for spinal shear force [12]. Pushing force requirements associated with four patient transport tasks proposed by the AORN are listed in Table 1 [8]. Table 1 also provides a series of recommendations for the number of nurses and equipment needed to perform a task safely. These recommendations are based on pushing force limits recommended by researchers at the Liberty Mutual Insurance Research Institute for Safety [13]. Additional information about pushing force limits is discussed later.

Another problem with transporting patients is lifting occupied beds over small barriers, such as a door or elevator threshold. A basic biomechanical analysis (Fig. 1) shows that lifting an occupied bed over a barrier or door threshold requires a high amount of lifting force that easily could exceed the recommended weight limit (RWL) for

Table 1
Physical demands and recommendations for safe patient transport

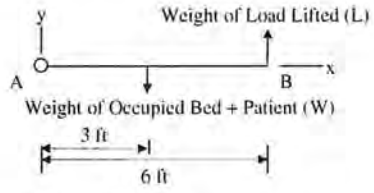
Transport task	Pushing force lb/(kg)		Max push distance ft/(m)		Ergonomic recommendation
Pushing an occupied stretcher	43.8 lb	(19.9 kg)	>200 ft	(60 m)	Task is acceptable for one caregiver
Pushing an occupied bed	50.0 lb	(22.7 kg)	<200 ft	(30 m)	Minimum of two caregivers required
Pushing an unoccupied specialty surgical bed	69.7 lb	(31.7 kg)	<100 ft	(30 m)	Recommend use of a powered transport device
Pushing an occupied specialty surgical bed	112.4 lb	(51.1 kg)	<25 ft	(7.5 m)	

safe manual lifting, even when two nurses perform the lift under ideal lifting conditions.

The following example is provided to show how a task easily could exceed the recommended lifting limits: if W (ie, the weight of the bed plus the weight of the patient) is 300 lb and the lift occurs at point B (the end of an occupied bed), then according to static equilibrium (see Equation 1 in Fig. 1), L is equal to 150 lb. This exceeds the RWL for lifting, as defined by the NIOSH lifting equation (NLE), even with two nursing personnel lifting the end of the occupied bed over a barrier under ideal conditions [10,11]

Proposed solutions

Two primary solutions are available for reducing the physical demands associated with transporting patients that exceed the recommended push/pull force limits for one person. These include the use of two or more persons to perform a task or the use of a powered transport device. If the required force exceeds the push/pull force limits for two caregivers or a task is performed frequently, then a powered transport device is suggested, although it is recognized these pieces of equipment are not available for every type of device that is transported with patients. If transporting patients requires lifting a bed or stretcher over a barrier, then a powered transport device reduces the risk for musculoskeletal disorder significantly for caregivers.



$$\sum \text{Moment}_z = (L \times 6) - (W \times 3) = 0 \quad \text{(Eq. 1)}$$

$$\sum \text{Moment}_z = L \times 6 = W \times 3$$

$$\sum \text{Moment}_z = \frac{W}{2} = L$$

Fig. 1. Simple biomechanical model of lifting occupied bed over barrier.

Safety tips

1. The height of a bed or stretcher should be positioned so that the hands are at a middle push point of 3 ft (0.92 m) from the floor. For tasks where the push point is lower than 3 ft (0.92 m), maximum and sustained push forces should be decreased by approximately 15% [8,13].
2. Manual patient transport tasks should not be performed more frequently than once every 30 minutes. For transport tasks performed more frequently than once every 30 minutes, a powered patient transport device is the best solution [8].
3. Pushing tasks are less physically demanding than pulling tasks [9].
4. If push force limits for one caregiver are exceeded (see Table 1), it is necessary to use two or more caregivers to complete the task or use a powered transport device. In some cases, even multiple caregivers may not be able to perform a task safely, especially if a bed or stretcher must be lifted over a door or elevator threshold [8].
5. The wheels on beds or stretchers need to be maintained properly to facilitate easier

transport. Wheels that are too small, casters that do not face forward easily, or wheels that are maintained poorly increase the amount of effort needed to complete the task.
6. When possible, select a transport route that has a minimum number of inclines, declines, or barriers, such as door or elevator thresholds to traverse.
7. Use bariatric equipment if patient weight exceeds the acceptable weight capacity for conventional patient handling equipment (the weight capacity usually is listed on the equipment). This may require special planning related to getting the equipment through standard-size doorframes and elevators. Bariatric equipment is designed specially with greater weight capacity than normal lifting assist equipment.

High-risk task #2: lateral patient transfers (eg, bed to stretcher)

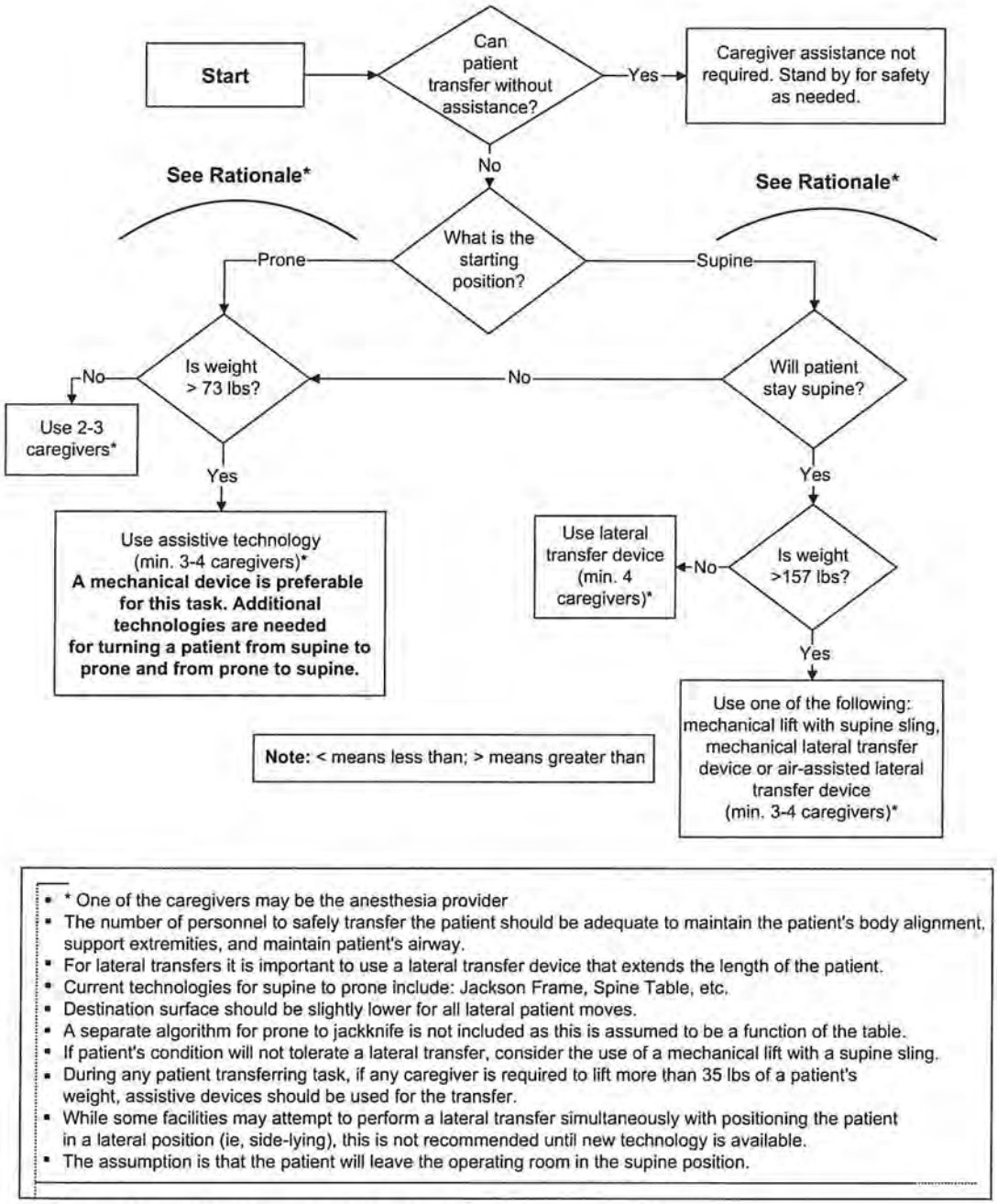
Description of the task

Nurses in critical care units often engage in lateral patient transfers (eg, laterally moving a patient in a lying position from one surface to another). This task often is completed with two or more caregivers pushing or pulling a patient laterally toward the destination position.

Physical demands

Both caregivers often must reach out with extended arms, either at the start or end of the task, to push or pull a patient from one surface (eg, a stretcher) to another surface (eg, a bed). The potential risk factors for this task include excessive pushing or pulling forces and extended reaches. These tasks may be more difficult when the height of nurses working together is disparate or when a patient resists movement, such as when a patient is confused or may be guarding a surgical wound. The likely result of excessive pulling or lifting forces generated during this task is high resultant spinal shear and compression forces that may exceed the recommended spinal compression or shear force load tolerance limits of the spinal tissues or excessive shoulder loading. The amount of pulling force required for this task is dependent on patient weight and the coefficient of friction between the sliding surfaces, which is a measure of the degree of slipperiness between a patient and bed surface or between the sheet under a patient and a bed surface. As the slipperiness or smoothness between the surfaces increases, the required pulling force decreases. Data for determining the maximum pulling force limit is published by researchers at the Liberty Mutual Insurance Research Institute for Safety. According to these, the maximum pulling force acceptable to 75% of women is 51 lb (23 kg) for maximum initial pulls; the 51-lb maximum pulling force value is for one caregiver. The actual required pulling force may be difficult to determine. As a rule of thumb, without a friction-reducing device, the required pulling force to move a patient is approximately 75% of a patient's body weight [14]. With newer sliding sheets, the required pulling force may be as low as 25% of a patient's body weight [14].

Based on published pulling strength data, the AORN published an ergonomic tool for assessing lateral transfers of patients between a stretcher and an operating room bed. The ergonomic tool is shown in Fig. 2. According to the AORN recommendation, the desirable approach for lateral transfer of patients involves use of a lateral transfer device, such as friction-reducing sheets, slider boards, or air-assisted transfer devices. If only a draw sheet is used without a lateral transfer device, care providers exert a pull force up to 72.6% of patient weight [8]. The AORN recommendation assumes that one caregiver or anesthesia care provider supports a patient's head and neck to maintain the airway during lateral transfers. The remaining mass of the patient's body equals 91.6% of his or her total body mass [8]. The rationale for the AORN recommendation is based on research indicating that for a pulling distance of 6.9 ft (2.1 m) or less, where the pull point (ie, starting point for the hands) is between a caregiver's waist and nipple line, and the task is performed no more frequently than once every 30 minutes, the maximum initial force required equals 57 lb (26 kg), and the maximum sustained force needed equals 35 lb (16 kg) [8]. According to the AORN recommendation, each caregiver safely can contribute a pull force required to transfer up to 48 lb, equal to 35 lb/0.726 (discussed previously). For one caregiver plus an anesthesia care provider, the maximum patient weight that safely can be transferred manually is 52.6 lb, equal to 48 lb/0.916 (described previously). For two caregivers plus an anesthesia care provider, a patient safely can be transferred manually weighing up to 104.8 lb, equal to (48 lb × 2)/0.916 (described previously). If there



- * One of the caregivers may be the anesthesia provider
- The number of personnel to safely transfer the patient should be adequate to maintain the patient's body alignment, support extremities, and maintain patient's airway.
- For lateral transfers it is important to use a lateral transfer device that extends the length of the patient.
- Current technologies for supine to prone include: Jackson Frame, Spine Table, etc.
- Destination surface should be slightly lower for all lateral patient moves.
- A separate algorithm for prone to jackknife is not included as this is assumed to be a function of the table.
- If patient's condition will not tolerate a lateral transfer, consider the use of a mechanical lift with a supine sling.
- During any patient transferring task, if any caregiver is required to lift more than 35 lbs of a patient's weight, assistive devices should be used for the transfer.
- While some facilities may attempt to perform a lateral transfer simultaneously with positioning the patient in a lateral position (ie, side-lying), this is not recommended until new technology is available.
- The assumption is that the patient will leave the operating room in the supine position.

* The rationale for this tool is provided in the AORN Guidance document [8].

Fig. 2. AORN ergonomic tool for assessing lateral transfer between stretcher and operating room bed. (Reprinted with permission from AORN. *AORN Guidance Statement: Safe Patient Handling and Movement in the Perioperative Setting.* Copyright © 2007 AORN, Inc., 2170 S Parker Rd, Suite 300, Denver, CO 80231. All rights reserved.)

are three caregivers plus an anesthesia care provider, then a patient safely can be transferred manually weighing up to 157.2 lb, equal to (48 lb × 3)/0.916 (described previously). If a patient weighs more than 157 lb, then the tool suggests that either a mechanical lifting device, mechanical lift with supine sling, mechanical lateral transfer device, or air-assisted lateral transfer device and a minimum of three to four caregivers be used.

Proposed solution

The best solution for a lateral transfer that exceeds the acceptable pulling force limits for one person is to add one or more nurses to do the job, use a friction-reducing device to reduce the pulling force, or use a powered lateral transfer device.

Tips for performing lateral patient transfer tasks safely

1. Previous research shows that there is no safe way to lift a patient manually from a bed to another bed, even with two nurses and ideal lifting conditions [12]. Therefore, this task should not be performed as a manual lift.
2. Historically, nurses have completed this task using a standard draw sheet or creatively inserting a plastic trash bag under the draw sheet to reduce friction. These strategies, however, do not reduce the risk sufficiently. Forces associated with excessive reaching and lumbar hyperflexion are reduced by 48% when a friction-reducing device is used compared with a draw sheet or trash bag. Subjective evaluations by nurses demonstrate that they preferred the use of a friction-reducing device to a standard draw sheet as a way to minimize musculoskeletal discomfort [15,16].
3. A friction-reducing device reduced effort significantly, by 25% for the spine and 33% for the shoulders [14].
4. Observations of nurses using these devices revealed the friction-reducing device was not intuitive in its use, and, despite training, nurses did not use it to its full capacity. Nurses should be required to demonstrate proficiency in the use of friction-reducing devices to assure appropriate use at onset and over time to fully use this type of patient care equipment [16].
5. Friction-reducing devices with long handles or straps reduce reach and associated forces on the back, shoulders, and arms significantly and are preferable to friction-reducing devices without long handles or straps [15].

High-risk task #3: moving patients to the head of a bed

Description of the task

Patients who are physically dependent and in bed need to be repositioned frequently to prevent pressure ulcers and other adverse events associated with immobility. Despite careful repositioning, over time, patients tend to shift downward in the bed and need to be pulled back to the head of the bed for comfort and safety.

Physical demands

This task is similar to the lateral transfer task (described previously), where a caregiver is standing at the side of a patient's bed. Because of the line of action of pulling a patient to the head of the bed, however, hand forces are parallel to the body rather than in-line with the front of the body, creating large lateral shear and torque forces on the spinal tissues. Additionally, to accomplish the task, caregivers often have to work with their arms extended fully, increasing the loads on the muscles, ligaments, and joints of the shoulder. When the arms are extended, the mechanical moment for the task is increased. An increase in the moment arm results in larger torque forces on the spine and shoulder. No limits for maximum acceptable torque forces on the spine are proposed, but studies show that axial rotation during lifting can increase the risk for low back pain in some workers [12]. Examination of the required muscle forces at the shoulder reveal that the maximum recommended force that an average woman is able to pull laterally across the body with arms extended fully is 22 lb (10 kg) or 11 lb (5 kg) per hand [8]. It is likely that the shoulder strength is exceeded before the lateral shear force limit is reached for most repositioning tasks, such as this. In addition, only approximately 44% of women have the torso strength capacity to do this task. The 44% value was determined using a 3-D strength prediction program developed by researchers at the University of Michigan [17].

Proposed solutions

There are only a few solutions available for this task. The best overall solution is to use a floor-based or ceiling-mounted patient lift that eliminates the need to pull or lift patients manually. Using a floor-based lift, however, is time consuming and may not be accepted readily by nurses. Use of a ceiling lift with a "disposable" repositioning sling that can stay under a patient improves the acceptance of such lift use. Skin integrity always is a concern when leaving slings under patients and must be considered. An alternative is to use a friction-reducing device and additional caregivers. This approach may reduce the

maximum required forces, but it does not solve the problem of pulling across the body.

Tips for moving patients to the head of a bed safely

1. This task requires two or more caregivers. It is unsafe to move an occupied bed away from a wall and attempt to lift a patient unassisted.
2. The task should be performed with caregivers positioned at the sides of a bed.
3. Pulling patients up in bed is made easier by lowering the head of the bed and raising the patient's knees [16].
   A. The forces on the shoulder can be decreased by 40% by raising the bed to an appropriate working height and angling the head of the bed downward to facilitate this repositioning task [16].
   B. The amount of musculoskeletal discomfort in performing this task also can be decreased by nearly 31% by angling the bed surface and raising a patient's knees before sliding them [16].
4. Additional research is needed to design technologic solutions for the high-risk, high-volume patient handling task of repositioning patients to the head of a bed.

High-risk task #4: repositioning patients in bed (eg, rolling from side to side)

Description of the task

Patients who are physically dependent and in bed need to be repositioned frequently to prevent pressure ulcers and other adverse events associated with immobility. Typically, this task is performed at least once every 2 hours, alternating between prone, right-side lying, supine, and left-side lying, as tolerated by patients. Thus, this task requires rolling patients from side to side.

Physical demands

This task is similar to the lateral transfer task described in task #2 and can be completed either by sliding patients to the center of a bed or lifting and moving patients to the center of a bed. For this task, however, it is likely that the arms are more extended for the maneuver than for a transfer from bed to bed. The same risk factors are involved and the same limitations apply as for the lateral transfer task. As with the transfer task, the required pulling force is dependent on patient weight and the coefficient of friction between a patient, or sheet under a patient, and bed surface. If the task is performed with arms extended directly in front of the body, then the shoulder strength or anterior-posterior shear on the spine likely is the limiting factor for this task. If, alternatively, the task is performed laterally by pulling across the body, then the limiting factor likely is shoulder strength or lateral shear (discussed previously).

Proposed solutions

There are few solutions available to reduce the physical demands associated with rolling patients from side to side in a bed. It may be possible to use a ceiling-mounted lift to assist in rolling patients from side to side, but use of a ceiling lift typically requires a manual rolling activity to place a sling under a patient. Alternately, two caregivers may be able to roll a patient manually without exceeding recommended pushing and pulling force limits, but the best technique is to use a lift with a repositioning sheet or strap to roll patients from side to side. Friction-reducing devices may be helpful with larger, heavier patients.

Tips for repositioning a patient in bed safely

1. Performing this task manually may require two or more caregivers, depending on patient weight.
2. A friction-reducing device or a mechanical lifting device should be used for bariatric patients or for patients whose pain or discomfort does not allow them to tolerate manual performance of the task.
3. One caregiver safely can reposition a patient laterally with the aid of a friction-reducing device or a ceiling-mounted lift.

Additional research, however, is needed to develop efficient, safe, user-friendly devices for assisting in rolling patients from side to side, especially as the average weight of patients continues to increase.

High-risk task #5: making occupied beds

Description of the task

Patients who are physically dependent and in critical care often are unable to get out of bed because of illness, pain, fatigue, or medical contraindications. Regardless, linens need to be changed regularly, particularly if patients are incontinent, bleeding, or perspiring. The task of

making an occupied bed can be challenging, particularly when patients are obese, hooked to multiple lines, or combative or uncooperative. This task often requires that caregivers roll patients from side to side to make a bed.

Physical demands

To perform this task, nurses usually approach patients from the side of a bed, roll patients onto their side, slide a sheet under patients, then move to the other side of the bed to roll patients back onto the sheet and then onto their other side, then pull the sheet out from under the patients, finally rolling patients onto their back to finish making the bed. The potential risk factors for this task are excessive pushing and pulling forces, excessive reach, and twisting. The other problem is that nurses often have to hold patients up with one hand while using the other hand to arrange the sheet. The pushing/pulling forces required to perform this task are dependent on the individual and how much assistance can be provided by patients. Again, the task likely is performed with arms in a fully extended position. The pushing or pulling force limit for this task likely is determined by shoulder strength limits for most women rather than the spinal shear force. Also, the task may need to be performed with one arm, because the other arm may be needed to hold patients on their side while inserting or removing a sheet under the patient.

Proposed solutions

There are few solutions available to reduce the physical demands associated with making an occupied bed. It is possible to use a ceiling-mounted lift to lift the patient off the bed, allowing for a hands-free approach to making a bed. As discussed previously, one of the most stressful elements of this task is rolling patients onto one side to get the sheet under them and then holding them in place. As discussed previously for the patient rolling task, two caregivers may be able to roll patients manually without exceeding recommended pushing and pulling force limits. Reaching and pulling patients, however, should be avoided when feasible.

Tips for making occupied beds safely

1. Raise the bed to an acceptable comfortable working height (about the level of the elbow) [15]. When two or more nurses are completing this task and they are of disparate heights, the acceptable bed height should be set approximately at the average elbow height of the two nurses.
2. Further, avoid twisting and excessive reach while performing this task. Nurses who move back and forth along the side of the bed, rather than twist in place, reduce musculoskeletal strain by 58% (60% back and 57% shoulders) [16].
3. This task is more difficult with some air mattresses or overlays, which can cause increased external forces when rolling patients toward and away from a caregiver, as required during the execution of this task [16].

High-risk task #6: applying antiembolism stockings

Description of the task

Many patients in critical care units are at risk for developing a deep vein thrombosis. One strategy used to prevent deep vein thromboses is the use of antiembolism stockings. In critical care, this task nearly always is performed while patients are supine.

Physical demands

The physical demands of this task are associated with (1) lifting and holding a leg for an extended period, (2) the awkwardness of performing a task that takes two hands (sliding the stockings up the leg) while holding a leg in place, (3) resistance of extending tight elastic stockings open to fit a leg inside, and (4) long duration of the task. The risk factor for this task is lifting and holding the weight of a leg for an extended period of time and the excessive force needed to apply stockings that intentionally are tight fitting. Guidelines for lifting a leg have been developed based on acceptable muscle strength and muscle fatigue guidelines for women. The limits are shown on Table 2 [8].

As can be seen in Table 2, the only acceptable manual lift of a leg is a two-handed lift for patients weighing less than 54 kg (120 lb) and for a holding duration of 1 minute or less. Performing a two-handed lift and applying the antiembolism stockings are not recommended for one caregiver.

Proposed solutions

One solution for lifting and holding a leg is a mechanized lift with a strap or sling designed for

Table 2
Recommended limits for lifting legs

Patient Weight lbs (kg)	Estimated Weight of Leg lbs (kg)		Lift 1- hand	Lift 2- hand	Hold 2-hand ≤1 min	Hold 2-hand ≤2 min	Hold 2-hand ≤3 min
≤140 lbs	≤22 lbs	(10 kg)					
>140 lbs	>22 lbs	(10 kg)					

Key

No shading	OK to lift and hold, use clinical judgment, do not hold longer than noted
Heavy shading	Do not lift alone, use assistive device or more than one caregiver

lifting body parts. For applying antiembolism stockings, there are commercially available products; one device works like a shoehorn, making the task easier, whereas another is simply a plastic sleeve placed over the foot before application to reduce friction.

Tips for applying antiembolism stockings safely

1. Applying antiembolism stockings from the bottom of the bed with a pushing movement significantly reduces muscle activity by 25% compared with applying stockings from the side, where a combination of lifting and pulling is required [16].
2. Applying lotion to the legs, before manual application of the stockings, is found to reduce the force needed to apply the stockings slightly, although this may be contraindicated if there are wounds or other skin conditions on or near the legs.

High-risk task #7: lifting or moving heavy objects and equipment

Description of the task

Patient care often includes use of equipment, devices, and supplies that need to be brought to a bedside. Often, these items are heavy or awkward to carry or push and the distance can be significant.

Physical demands

Critical care nurses often are required to lift and move various heavy objects and equipment manually, often in awkward body postures. The risk factor for this task is potential excessive spinal compression force or shear force. As the weight of an object or the horizontal distance of the load relative to a worker increases or as the posture becomes more awkward, the compression force increases and the acceptable amount of weight that can be lifted safely decreases. The revised NIOSH lifting equation (NLE) is an assessment tool used to evaluate the physical demands resulting from specified two-handed manual lifting tasks [10,11]. To use the NLE, specific information is needed, such as the weight of the object, the horizontal reach distance, the vertical height from which the object will be lifted, and other factors described in the NLE applications manual [10,11]. The principal products of the NLE are the recommended weight limit (RWL) and the lifting index (LI) for a specified lift. The RWL is defined for a specified lift as the weight of load that nearly all healthy workers can perform for that task over a substantial period of time (eg, up to 8 hours) without an increased risk for developing lifting-related low back pain. The LI value is a term that provides a relative estimate of the level of physical stress associated with a particular manual lifting task and is defined as the weight of load to be lifted (L) divided by the RWL (ie, LI = L/RWL). According to NIOSH, it is likely that lifting tasks with an LI greater than 1.0 pose an increased risk for lifting-related low back pain for a fraction of the population and that many workers are at risk if the LI value exceeds 3.0.

As with several other tasks (discussed previously), the AORN developed a series of recommendations for a set of lifting tasks performed often in operating rooms [8]. These recommendations are based on the LI values calculated for these tasks (Table 3). The NLE can be used to

Table 3
National Institute for Occupational Safety and Health lifting index value for typical lifting tasks performed in operating rooms

Lifting Task	Lifting Index	Lifting Recommendation*
3000 cc irrigation fluid	<0.2	
Sand Bags	0.3	
Linen Bags	0.4	
Lead aprons	0.4	
Custom sterile packs (heart or spine)	0.5	
Garbage Bags (full)	0.7	
Positioning Devices off shelf or rack (stirrups)	0.7	
Positioning Devices off shelf or rack (gelpads)	0.9	
Hand table (49" x 28")-largest hand table-used infrequently	1.2	
Flouro Board (49" x 21")	1.2	
Stirrups (2- one in each hand)	1.4	
Wilson frame	1.4	
Irrigation containers for lithotripsy (12,000 ml)	1.5	
Instrument Pans	2.0	

Key

No shading	Minimal risk – Safe to Lift for one person
Light shading	Potential risk – Two or more persons should perform the lift or assistive lifting equipment should be used.
Heavy shading	Considerable risk – Use assistive technology, as available

calculate the RWL and LI for other two-handed manual lifting tasks performed by critical care nurses not listed in Table 3, such as lifting intravenous pumps to attach to a bed for patient transport; moving chairs to accommodate visitors; lifting equipment to the end a bed; transporting monitors; moving heavy bottled gas tanks; and lifting beds and carts over electric cords or cables in patient rooms. Those interested in more details of the NLE should refer to the NIOSH applications manual [10,11].

Nurses also often have to push or pull wheeled equipment or carts. These tasks have risk factors as described for pushing an occupied operating room bed (discussed previously). The amount of force required to push or pull these items determines whether or not they can be done safely. The AORN presented a recommendation for pushing and pulling wheeled items in an operating room work environment (listed in Table 4). For items not listed in Table 4, the guide in Table 5 can be used to assess the acceptability of a specific pushing task. If the required pushing force exceeds the value in Table 5 for the selected distance, then the task should not be performed by one caregiver. Pushing force limits for multiple caregivers can be calculated by multiplying the values in Table 5 by the number of caregivers. It is not recommended, however, that more than two caregivers push equipment. As noted in Table 4, the appropriate solution is to use a powered assist device.

Proposed solutions

The best approach for lifting loose objects and equipment is to have two persons perform the lift or use lifting assist equipment (see Table 3). The determinant of whether or not to use a single lifter, multiple lifters, or assistive equipment is the weight of the load to be lifted, the frequency of lifting, and the accessibility to reach and lift the equipment. As a rule of thumb, for lifts that are performed often or every day, assistive lifting technology likely is the best choice.

Tips for lifting or moving heavy equipment safely

1. Pushing tasks ergonomically are preferred over pulling tasks.
2. Ensure that push handles are at a correct push height of approximately 3 ft (0.92 m).

Table 4
Association of periOperative Registered Nurses recommendations for pushing wheeled equipment

OR Equipment	Pushing Force lb / (kg)	Max Push Distance ft / (m)	Ergonomic Recommendation
Electro-cautery unit	**8.4 lb** (3.8 kg)	**>200ft** (60m)	Task is acceptable for 1 caregiver
Ultrasound	**12.4 lb** (5.6 kg)	**>200ft** (60m)	
X ray equipment portable	**12.9 lb** (5.9 kg)	**>200ft** (60m)	
Video towers	**14.1 lb** (6.4 kg)	**>200ft** (60m)	
Linen cart	**16.3 lb** (7.4 kg)	**>200ft** (60m)	
X ray equip - C arm	**19.6 lb** (8.9 kg)	**>200ft** (60m)	
Case carts – empty	**24.2 lb** (11.0 kg)	**>200ft** (60m)	
OR Stretcher unoccupied	**25.1 lb** (11.4 kg)	**>200ft** (60m)	
Case carts – full	**26.6 lb** (12.1 kg)	**>200ft** (60m)	
Microscopes	**27.5 lb** (12.5 kg)	**>200ft** (60m)	
Hospital Bed – unoccupied	**29.8 lb** (13.5 kg)	**>200ft** (60m)	
Specialty equip carts	**39.3 lb** (17.9 kg)	**>200ft** (60m)	
OR Stretcher - occupied 300 lb	**43.8 lb** (19.9 kg)	**>200ft** (60m)	
Bed - occupied 300 lb	**50.0 lb** (22.7 kg)	**<200ft** (30m)	Min 2 caregivers required
Specialty OR beds unoccupied	**69.7 lb** (31.7 kg)	**<100ft** (30m)	
OR bed unoccupied	**61.3 lb** (27.9 kg)	**<25ft** (7.5m)	Recommend powered transport device
OR bed occupied 300 lb	**112.4 lb** (51.1 kg)	**<25ft** (7.5 m)	
Specialty OR beds - occupied 300 lb	**124.2 lb** (56.5 kg)	**<25ft** (7.5 m)	

Key

No shading	Minimal risk - Task is acceptable for 1 caregiver
Light shading	Moderate risk – Minimum of 2 caregivers or powered device recommended
Heavy shading	Considerable risk - Recommend powered transport device

3. For tasks where the vertical height of the push point is less than 3 ft (0.92 m) above the floor, maximum and sustained push forces are decreased by approximately 15%.
4. For tasks performed more frequently than once every 30 minutes, maximum and sustained push forces are decreased by approximately 6%.
5. If push force limits are exceeded, it is necessary to reduce the weight of the load, use two or more caregivers to complete the task together, or use a powered transport device. Powered transport devices are built into some beds and stretchers; additionally, there are devices available commercially to move equipment [18].
6. Equipment or casters need to be maintained properly to assist in moving equipment more easily.
7. These recommendations are based on the Liberty Mutual psychophysical limits for push forces, where hands are positioned at a middle push point of 3 ft (0.92 m) from the floor or above and tasks are performed no more frequently than once every 30 minutes [13].

Discussion

Many manual handling tasks performed by critical care nursing staff (eg, handling and moving patients, beds, and equipment) require high levels of physical effort, resulting in significantly high internal loads on muscles, ligaments, and joints of the body, especially the shoulder and low back. These high internal loads significantly increase the potential for development of WMSDs for these workers.

Table 5
Push force limits

Push Forces Based on Design Goal of acceptablity to 75% of Women					
Distance (ft)	25	50	100	150	200
Initial (lbs)	51	44	42	42	37
Sustained (lbs)	30	25	22	22	15

Adapted from Snook and Ciriello, 1991 [13]

Adapted from Snook SH, Ciriello VM. The design of manual handling tasks: revised tables of maximum acceptable weights and forces. Ergonomics 1991;34(9):1197–213; with permission.

Fortunately, there are alternatives to unsafe manual handling tasks, such as use of floor-based and ceiling lifts, lateral transfer devices, slip sheets, antiembolism stocking applicators, and powered transport devices [19]. In addition, new technologies rapidly are being developed for a wide range of health care settings. As discussed in this article, solutions for many of the high-risk tasks found in critical care nursing currently are available.

Critical care nurses often are asked to perform complex tasks that are time sensitive and require a rapid response. There may not always be time to look for the proper equipment to perform a task unless the assistive equipment is in close proximity to workers. Therefore, it is important that adequate equipment is available and that the most appropriate equipment is selected for the task. For example, for transferring tasks requiring a full-body lift, a ceiling lift might be preferred over a floor-based lifting device, because the ceiling lift always is in close proximity to the work area, and nurses do not have to go looking for the lift. In addition, the problem of storage of floor-based lifts is eliminated by the use of ceiling lifts, which are stored on an overhead track and do not take up any floor space. It is important that the culture of the work environment in critical care settings be changed so that caregivers and management make a significant effort to provide adequate equipment and training necessary to prevent the equipment from simply being stored in a back room.

In this article, tasks with high risk for musculoskeletal disorders in critical care settings are identified clearly and appropriate solutions presented. Previous studies have shown that implementation of a safe patient handling and movement program that incorporates the use of this new technology can pay for itself in a short period of time and provide a long-term benefit for health care facilities and the nursing staff [20,21].

Efforts to improve the safety of critical care nurses are essential to assure quality patient care. Nurses who are injured or suffer from musculoskeletal pain may not be able to provide rapid and effective responses when urgent patient care is needed. Insuring the health and safety of critical care nurses also will help alleviate the current nursing shortage by keeping nurses on the job longer, reducing the risk for disruption of nursing practice, and reducing the risk for a premature career-ending injury.

References

[1] Collins JW, Menzel NN. Scope of the problem. In: Nelson A, editor. Safe patient handling and movement: a practical guide for health care professionals. New York: Springer Publishing; 2006. p. 1–26.

[2] U.S. Department of Labor, Bureau of Labor Statistics. Lost-work time injuries and illnesses: characteristics and resulting time away from work, 2000. Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics; 2002.

[3] U.S. Department of Labor (Bureau of Labor Statistics). (2000). Table R6: incidence rates for nonfatal occupational injuries and illnesses involving days hawai from work per 10,000 full-time workers by industry and selected parts of body affected by injury or illness, 2000. Accessed September 13, 2006. Available at: http://www.bls.gov/iif/oshwc/osh/case/ostb1039.pdf.

[4] U.S. Department of Labor. Bureau of Labor Statistics. (2004). Nonfatal cases involving days away from work: selected characteristics. Accessed September 13, 2006. Available at: http://data.bls.gov/labjava/outside.jsp?survey=cd.

[5] Smedley J, Egger P, Cooper C, et al. Manual handling activities and risk of low back pain in nurses. Occup Environ Med 1995;52:160–5.

[6] Nelson AL, Fragala G, Menzel N. Myths and facts about back injuries in nursing. American Journal of Nursing 2003;103(2):32–40.

[7] Nelson AL, and Baptiste A. (2004). Evidence-based practices for safe patient handling and movement. Online J Issues Nurs, 19 (3) Manuscript 3. Available at: www.nursingworld.org/ojin/topic25/tpc25_3.htm.
[8] AORN. AORN Guidance Statement: Safe Patient Handling and Movement in the Perioperative Setting. Denver (CO): AORN Publications; 2007.
[9] Chengalur SN, Rodgers SH, Bernard TE. Kodak's ergonomic design for people at work. 2nd edition. New York: John Wiley & Sons, Inc; 2004.
[10] Waters T, Putz-Anderson V, Garg A, et al. Revised NIOSH equation for the design and evaluation of manual lifting tasks. Ergonomics 1993;36 no 7: 749–76.
[11] Waters T, Garg A, Putz-Anderson V. Applications manual for the revised NIOSH lifting equation [DHHS(NIOSH) Pub. No. 94–110]. Cincinnati (OH): Department of Health and Human Services, National Institute for Occupational Safety and Health, Division of Biomedical and Behavioral Science; 1994.
[12] Marras WS, Davis KG, Kirking BC, et al. A comprehensive analysis of low back disorder risk and spinal loading during the transferring and repositioning of patients using different techniques. Ergonomics 1999;42(7):904–26.
[13] Snook SH, Ciriello VM. The design of manual handling tasks: revised tables of maximum acceptable weights and forces. Ergonomics 1991;34(9): 1197–213.
[14] Lloyd JD, Baptiste A. Biomechanical evaluation of friction reducing devices for lateral patient transfers. AAOHN J 2006;54(3):113–9.
[15] Baptiste A, Boda S, Nelson A, et al. Friction-reducing devices for lateral patient transfers: a clinical evaluation. AAOHN J 2006;54(4):173–80.
[16] Nelson AL, Lloyd J, Menzel N, et al. Preventing nursing back injuries: redesigning patient handling tasks. AAOHN J 2003;51(3):126–34.
[17] Chaffin DB, Andersson GBJ, Martin BJ. Occupational biomechanics. 3rd edition. New York: John Wiley & Sons, Inc.; 1999.
[18] VISN 8 Patient Safety Center of Inquiry. (2005). Technology resource guide. Accessed September 14, 2006. Available at: http://www.visn8.med.va.gov/visn8/patientsafetycenter/safePtHandling/default.asp.
[19] Safe patient handling and movement: a practical guide for health care professionals. In: Nelson A, editor. New York: Springer Publishing; 2006.
[20] Collins JW, Wolf L, Bell J, et al. An evaluation of a "best practices" musculoskeletal injury prevention program in nursing homes. Inj Prev 2004;10:206–11.
[21] Nelson AL, Owen B, Lloyd J, et al. Safe patient handling & movement. American Journal of Nursing 2003;103(3):32–43.