Safe Patient Handling and Movement Series

AORN Ergonomic Tool 7:

Pushing, Pulling, and Moving Equipment on Wheels

THOMAS WATERS, PhD, CPE; **JOHN D. LLOYD,** PhD, MErgS, CPE;
EDWARD HERNANDEZ, BSN, RN; **AUDREY NELSON,** PhD, RN, FAAN

ABSTRACT

Pushing and pulling equipment in and around the OR can place high shear force demands on perioperative team members' shoulder and back muscles and joints. These high forces may lead to work-related musculoskeletal disorders. AORN Ergonomic Tool 7: Pushing, Pulling, and Moving Equipment on Wheels can help perioperative team members assess the risk of pushing and pulling tasks in the perioperative setting. The tool provides evidence-based suggestions about when assistive devices should be used for these tasks and is based on current ergonomic safety concepts, scientific evidence, and knowledge of effective technology and procedures, including equipment and devices for safe patient handling. *AORN J* 94 (September 2011) 254-260. Published by Elsevier, Inc., on behalf of AORN, Inc. doi: 10.1016/j.aorn.2010.09.035

Key words: *musculoskeletal disorders, back injuries, ergonomic interventions, moving equipment.*

Editor's note: *This is the last in a series of seven articles based on the "AORN guidance statement: Safe patient handling and movement in the perioperative setting." These articles describe specific ergonomic solutions for high-risk patient handling tasks in the perioperative clinical setting.*

Much of the work performed by nurses and other perioperative caregivers involves pushing and pulling heavy equipment in and around the OR and between ORs. Objects to be pushed or pulled typically include occupied and unoccupied beds (eg, regular patient beds, OR beds), supply carts, and heavy wheeled equipment. These pushing and pulling tasks may increase a worker's risk of developing work-related musculoskeletal disorders, such as back or shoulder injuries.[1] Pushing and pulling tasks should be assessed to determine whether they are safe to perform manually, and caregivers should use recommendations based on scientific evidence to determine whether assistive technology is needed to perform the task.

doi: 10.1016/j.aorn.2010.09.035

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OR Equipment	Pushing		Max Push Distance ft/(m)		Ergonomic Recommendation
Electrosurgery unit	8.4 lbF	(3.8 kgF)	>200 ft	(60 m)	
Ultrasound	12.4 lbF	(5.6 kgF)	>200 ft	(60 m)	
X-ray equipment portable	12.9 lbF	(5.9 kgF)	>200 ft	(60 m)	
Video towers	14.1 lbF	(6.4 kgF)	>200 ft	(60 m)	
Linen cart	16.3 lbF	(7.4 kgF)	>200 ft	(60 m)	
X-ray equipment, C-arm	19.6 lbF	(8.9 kgF)	>200 ft	(60 m)	
Case carts, empty	24.2 lbF	(11.0 kgF)	>200 ft	(60 m)	
OR stretcher, unoccupied	25.1 lbF	(11.4 kgF)	>200 ft	(60 m)	
Case carts, full	26.6 lbF	(12.1 kgF)	>200 ft	(60 m)	
Microscopes	27.5 lbF	(12.5 kgF)	>200 ft	(60 m)	
Hospital bed, unoccupied	29.8 lbF	(13.5 kgF)	>200 ft	(60 m)	
Specialty equipment carts	39.3 lbF	(17.9 kgF)	>200 ft	(60 m)	
OR stretcher, occupied, 300 lbs	43.8 lbF	(19.9 kgF)	>200 ft	(60 m)	
Bed, occupied, 300 lbs	50.0 lbF	(22.7 kgF)	<200 ft	(30 m)	Min two care-givers required
Specialty OR beds, unoccupied	69.7 lbF	(31.7 kgF)	<100 ft	(30 m)	
OR bed, unoccupied	61.3 lbF	(27.9 kgF)	<25 ft	(7.5 m)	Recommend powered transport device
OR bed, occupied, 300 lbs	112.4 lbF	(51.1 kgF)	<25 ft	(7.5 m)	
Specialty OR beds, occupied, 300 lbs	124.2 lbF	(56.5 kgF)	<25 ft	(7.5 m)	

No shading Minimal risk—Safe to lift
Light shading Potential risk—Use assistive technology as available
Heavy shading Considerable risk—One person should not perform alone or weight should be reduced

Figure 1. AORN Ergonomic Tool 7: Recommendations for Pushing, Pulling, and Moving Equipment on Wheels.

BACKGROUND

Pushing and pulling tasks create a different type of force on the spine than do lifting tasks. While lifting creates large compression forces on the spinal discs and other structures of the spine, pushing and pulling creates predominantly high shear forces. Shear force tolerance limits for the spinal discs, however, are believed to be significantly lower (ie, about one-third lower) than tolerance limits for discs in compression.[2] Therefore, it is important for perioperative personnel to limit their amount of exposure to shear force. A 2009 study by Marras et al[2] showed that shear forces associated with pushing or pulling could easily exceed the recommended limits for these tasks. Recommended exposure limits for pushing and pulling forces have been published based on studies by researchers at Liberty Mutual Insurance.[3] These pushing and pulling force limits have been used by ergonomists to assess the acceptability of pushing and pulling tasks in industry.

ERGONOMIC TOOL 7

AORN Ergonomic Tool 7: Pushing, Pulling, and Moving Equipment on Wheels (Figure 1) provides guidance on whether a specific manual pushing and pulling task should be performed by one or two caregivers.[4] The tool lists a variety of typical objects pushed and pulled by caregivers in the perioperative environment, the estimated required pushing force for each device, and the maximum recommended distance

the device can be pushed. Maximum pushing distances were determined based on Liberty Mutual psychophysical limits.[3] All results are presented in both US and metric units. For example, moving an occupied hospital bed with a patient weighing 300 lb (136 kg) requires 50.0 lb (22.7 kg) of pushing force. This task exceeds the recommended exposure limit for one caregiver, but the task could be performed by two caregivers. The total distance acceptable for moving the bed, however, is less than 200 ft. Similarly, pushing an OR bed occupied with a 300-lb patient requires a force of 112.4 lb (51.1 kg) and is considered unacceptable to perform manually, even with two caregivers. For this task, a powered transport device is recommended. Pushing an occupied standard hospital bed, standard OR bed, or specialty OR bed—whether occupied or not—presents a moderate-to-high risk of injury to the caregiver. For these situations, having a minimum of two caregivers participate in the transport task or use of a powered transport device is strongly recommended.

RECOMMENDATIONS

Based on Liberty Mutual psychophysical push and pull force limits, the optimal design conditions for pushing and pulling tasks include task frequencies less than once every 30 minutes, with the hands positioned at a middle vertical height of approximately 3 ft (0.92 m) above the floor, and a horizontal push or pull distance less than 25 ft (7.6 m).[3] Pushing tasks are ergonomically preferable compared with pulling tasks.[5] The optimal push-point height for push handles is approximately 3 ft (0.92 m) above the floor. Equipment and casters must be properly maintained to facilitate moving.

Tasks in which the push point is lower than 3 ft require that maximum and sustained push forces be decreased by approximately 15%. For tasks performed more frequently than once every 30 minutes, maximum and sustained push forces should be decreased

Articles in This Series

Ogg M. Introduction to the safe patient handling and movement series. *AORN J.* 2011;93(3):331-333.

Waters T, Baptiste A, Short M, Plante-Mallon L, Nelson A. AORN Ergonomic Tool 1: Lateral transfer of a patient from a stretcher to an OR bed. *AORN J.* 2011;93(3):334-339.

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Waters T, Spera P, Petersen C, Nelson A, Hernandez E, Applegarth S. AORN Ergonomic Tool 3: Lifting and holding the patient's legs, arms, and head while prepping. *AORN J.* 2011;93(5):589-592.

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Waters T, Baptiste A, Short M, Plante-Mallon L, Nelson A. AORN Ergonomic Tool 6: Lifting and carrying supplies and equipment in the perioperative setting. *AORN J.* 2011;94(2):173-179.

Waters T, Lloyd JD, Hernandez E, Nelson A. AORN Ergonomic Tool 7: Pushing, pulling, and moving equipment on wheels. *AORN J.* 2011;94(3):254-260.

TABLE 1. Push-Pull Forces Based on Design Goal of Acceptable Limits for 75% of Women Caregivers

Distance	25 ft	50 ft	100 ft	150 ft	200 ft
Initial force	51 lb (32.1 kg)	44 lb (19.9 kg)	42 lb (19.0 kg)	42 lb (19.0 kg)	37 lb (16.7 kg)
Sustained force	30 lb (13.6 kg)	25 lb (11.3 kg)	22 lb (9.9 kg)	22 lb (9.9 kg)	15 lb (6.8 kg)

by approximately 6%. If push force limits are exceeded, it is necessary to reduce the weight of the load, have two or more caregivers complete the task together, or use a powered transport device.

For OR equipment not listed in the tool, caregivers should measure the required hand force and compare that force with the recommended push/pull limits shown in Table 1. If the required hand force exceeds the recommended limits, then additional caregivers or use of a powered transport device is recommended.

RATIONALE AND CALCULATIONS

We measured pushing forces in newtons for each item of equipment listed in Table 2. Initial force is defined as the peak force to initially propel the item. Sustained force is defined as the minimum force required to maintain equipment propulsion. Initial wheels-turned force was defined as the peak initial force when the wheels on the equipment were turned perpendicular to the desired direction of travel. We computed the averages across five repeated trials for each condition and item and converted the amounts into US units (ie, pounds).

Maximum pushing distances were determined on the basis of Liberty Mutual's push-force limits.[3] The shortest acceptable push distance, determined on the basis of both initial and sustained forces, was used. These values are based on the assumption that the operator's hands are positioned at a middle push point of 3 ft or more above the floor and that the task is performed no more frequently than once every 30 minutes.

For OR equipment not listed in the tool, the simple, low-cost method shown in Figure 2 can be used for measuring the forces required for pushing or pulling objects such as beds, carts, and transfer equipment. Perioperative personnel can use a broom handle or other lightweight cylindrical object taped to a bathroom scale to measure pushing force (the required pulling force would be identical to the required pushing force). Personnel can place a scale against the object to be pushed and slowly apply force to the broom handle until the object moves. The individual performing this task can then read the maximum required pushing force on the weight scale. The scale used in this method should provide a continuous readout of applied force to indicate the maximum value.

To obtain the best estimate of the actual maximum force, multiple measurements should be obtained and a second individual can repeat the measurement several times and average the values. The mean value can then be compared with the maximum recommended push force values. For example, assume that the force required to push a cart was measured as 52 lb. Because women generally have less strength than men, this task would not be acceptable for one woman for any distance, but it would be acceptable for two women assuming each pushed 26 lb, for a distance of up to 25 ft. Use of a powered transport device would be recommended if only one woman were available to push the cart.

CONCLUSION

There is evidence that some pushing and pulling tasks create high spinal shear forces that could result in injury and potential disability for health

TABLE 2. Measured Push Force for OR Equipment

Item	Type of force	Force in newtons, measured in 5 trials					Mean force		Maximum push distance in feet
		1	2	3	4	5	Newtons	Pounds	
Electrosurgical unit	Initial	30	35	35	30	30	32.0	7.2	> 200
	Sustained	10	10	10	10	10	10.0	2.2	> 200
	Initial (wheels turned)	40	35				37.5	8.4	> 200
OR stretcher, unoccupied	Initial	62	70	65	75		68.0	15.3	> 200
	Sustained	20	20	25	25	25	23.0	5.2	> 200
	Initial (wheels turned)	113	110				111.5	25.1	> 200
OR stretcher, occupied, 300 lb	Initial	120	120	120	115	120	119.0	26.8	> 200
	Sustained	30	35	30	40	40	35.0	7.9	> 200
	Initial (wheels turned)	210	180				195.0	43.8	< 50
Bed, unoccupied	Initial	115	120	125	110	105	115.0	25.9	> 200
	Sustained	30	25	30	25		27.5	6.2	> 200
	Initial (wheels turned)	130	135				132.5	29.8	> 200
Bed, occupied, 300 lb	Initial	170	160	167	135	155	157.4	35.4	> 200
	Sustained	40	50	50	40	60	48.0	10.8	> 200
	Initial (wheels turned)	230	215				222.5	50.0	< 25
OR bed, unoccupied	Initial	218	275	245	280	270	257.6	57.9	< 25
	Sustained	120	125	120	100	120	117.0	26.3	< 25
	Initial (wheels turned)	270	275				272.5	61.3	< 25
OR bed, occupied, 300 lb	Initial	425	432	445	405	325	406.4	91.4	< 25
	Sustained	180	180	180			180.0	40.5	< 25
	Initial (wheels turned)	485	515				500.0	112.4	< 25
Specialty OR bed, unoccupied	Initial	175	182	190	260	200	201.4	45.3	< 25
	Sustained	100	100	100			100.0	22.5	< 100
	Initial (wheels turned)	305	315				310.0	69.7	< 25
Specialty OR bed, occupied, 300 lb	Initial	365	290	320	305	305	317.0	71.3	< 25
	Sustained	140	160	140	115	115	134.0	30.1	< 25
	Initial (wheels turned)	560	545				552.5	124.2	< 25
Microscope	Initial	62	75	80	75	75	73.4	16.5	> 200
	Sustained	20	25	20	25	25	23.0	5.2	> 200
	Initial (wheels turned)	125	120				122.5	27.5	< 50
Case cart, full	Initial	62	108	75	108		88.3	19.8	> 200
	Sustained	30	40	40	40		37.5	8.4	> 200
	Initial (wheels turned)	122	115				118.5	26.6	> 200
Case cart, empty	Initial	60	65	65	62	65	63.4	14.3	> 200
	Sustained	40	30	35	40	35	36.0	8.1	> 200
	Initial (wheels turned)	120	95				107.5	24.2	> 200
X-ray equipment, C-arm	Initial	100	75	100	75	85	87.0	19.6	> 200
	Sustained	20	25	25	25	25	24.0	5.4	> 200
	Initial (wheels turned)	N/A	N/A				N/A	N/A	N/A
X-ray equipment, portable	Initial	60	55	55	60	58	57.6	12.9	> 200
	Sustained	25	30	30	30	30	29.0	6.5	> 200
	Initial (wheels turned)	N/A	N/A				N/A	N/A	N/A

TABLE 2. (*continued*) Measured Push Force for OR Equipment

Item	Type of force	Force in newtons, measured in 5 trials					Mean force		Maximum push distance in feet
		1	2	3	4	5	Newtons	Pounds	
Video tower	Initial	35	40	40	35	35	37.0	8.3	> 200
	Sustained	15	20	20	15	20	18.0	4.0	> 200
	Initial (wheels turned)	60	65				62.5	14.1	> 200
Ultrasonography unit	Initial	35	40	45	45	40	41.0	9.2	> 200
	Sustained	20	20	25	20	20	21.0	4.7	> 200
	Initial (wheels turned)	55	55				55.0	12.4	> 200
Specialty equipment cart	Initial	105	90	120	125	145	117.0	26.3	> 200
	Sustained	25	30	30	25	25	27.0	6.1	> 200
	Initial (wheels turned)	165	185				175.0	39.3	< 200
Linen cart	Initial	50	70	55	55	65	59.0	13.3	> 200
	Sustained	20	25	20	25	20	22.0	4.9	> 200
	Initial (wheels turned)	75	70				72.5	16.3	> 200

Blank spaces = data were not obtained; initial force = peak force to propel; initial force with wheels turned = the peak initial force when the wheels on the equipment were turned perpendicular to the desired direction of travel; N/A = not applicable; sustained force = minimum force required to maintain propulsion.

care professionals. For this reason, these individuals should use Ergonomic Tool 7 and other ergonomic guidelines to evaluate the manual forces needed to perform physically demanding pushing or pulling tasks to determine whether the force required exceeds recommendations. If these forces are found to be excessive, health care professionals should implement ergonomic interventions (eg, use of powered mobile equipment or powered tugger devices) to reduce exposure to these high spinal loads. AORN

Figure 2. A simple device for measuring required pushing force.

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

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Thomas Waters, PhD, CPE, is a senior research safety engineer at the National Institute for Occupational Safety and Health, Cincinnati, OH. *Dr Waters has no declared affiliation that could be perceived as posing a potential conflict of interest in the publication of this article.*

John D. Lloyd, PhD, MErgS, CPE, is the associate director of Health Science Research & Development Rehabilitation at the Patient Safety Center of Inquiry, James A. Haley Veterans Affairs Medical Center, Tampa, FL. *Dr Lloyd has no declared affiliation that could be perceived as posing a potential conflict of interest in the publication of this article.*

Edward Hernandez, BSN, RN, is an OR nurse manager at the James A. Haley Veterans Administration Hospital, Tampa, FL. *Mr Hernandez has no declared affiliation that could be perceived as posing a potential conflict of interest in the publication of this article.*

Audrey Nelson, PhD, RN, FAAN, is a chief nurse and director of nursing service for research in Health Science Research and Development/Rehabilitation Research and Development at the Center of Excellence and Maximizing Rehabilitation Outcomes at the James A. Haley Veterans Affairs Medical Center, Tampa, FL. *Dr Nelson has no declared affiliation that could be perceived as posing a potential conflict of interest in the publication of this article.*