Strategies for Providing Mechanical Ventilation in a Mass Casualty Incident: Distribution Versus Stockpiling

John Wilgis MBA RRT

Introduction
Planning and Preparedness
Partnership Engagement
Essential Education
Necessary Equipment
Distribution Versus Stockpiling
Summary

Federal funding provides state public and private health care systems the ability to build and maintain a reserve supply of ventilators for emergency response to mass casualty incidents. Studying and planning the ventilator reserve capability requires subject-matter expertise, identification of best mechanical-ventilation practices and quality care standards, and contingency planning. Natural disasters such as pandemic influenza, or man-made disasters such as bioterrorism could necessitate field use of numerous mechanical ventilators. This paper discusses the pros and cons of stockpiling ventilators at one site (to be distributed as needed to disaster areas) versus increasing the number of ventilators at all hospitals. Respiratory-device corporations, respiratory professional associations, and respiratory therapists should be involved in the planning and development of respiratory mass casualty response systems. Key words: alternative care standards, caching, emergency management, Health Resources and Services Administration, mass casualty incident, mechanical ventilation, preparedness planning, public health, ventilator. [Respir Care 2008;53(1):96–100. © 2008 Daedalus Enterprises]
mize patient outcomes in the face of health care needs that exceed available resources. The largest component of a response effort for patient surge is the resources that enable successful reaction. Human resources, especially qualified medical professionals, are in short supply, and the same can be said for certain medical products and vital equipment such as ventilators.

Planning and Preparedness

Ventilators are at the center of the preparedness planning and emergency management debate. Man-made or natural disaster could create a large number of victims who require mechanical ventilation. Though goals for improving hospital surge capacity are addressed in the guidelines from the Joint Commission (formerly the Joint Commission on Accreditation of Health Care Organizations), the National Bioterrorism Hospital Preparedness Plan, the Centers for Disease Control and Prevention Public Health Emergency Preparedness Web site (http://www.bt.cdc.gov), the Urban Area Security Initiative, and the Metropolitan Medical Response System, specific target requirements differ. Planning estimates and assumptions must consider several factors to enable states to properly care for people who need ventilator support.

At the top of the debate is the question of whether to stockpile ventilators in a strategic location and distribute them to disaster areas in the time of need, or instead to increase the number of ventilators at all hospitals and thus increase their response capability and avoid the distribution time in the stockpile strategy. Both plans are controversial, and each jurisdiction must weigh for itself the pros and cons of the 2 strategies. Plans that deal with the allocation of critical care resources present substantial challenges. Public and private county, regional, and state health officials must cohesively determine the best approach to preparing for a disaster that would require numerous ventilators.

Partnership Engagement

Various stakeholders are involved in planning and building emergency ventilator reserve capacity. Government agencies, the private business sector, hospital associations and spokespeople, and others are involved in the process. Response capability and recovery are directly tied to these relationships, and team engagement improves the chance of developing functional, operable response plans. A formal system of group development and process defines how members will deal with key issues in developing and managing the ventilator emergency-response capability. Table 1 lists concerns that planners and stakeholders must consider.

Table 1. Issues in Creating a Strategic Cache of Mechanical Ventilators

<table>
<thead>
<tr>
<th>Federal and state statutes that impact procurement and use</th>
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<tr>
<td>Available grant funding process</td>
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<td>Partner and leadership roles</td>
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<td>Technical equipment specifics</td>
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<td>Supply and inventory specifics</td>
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<td>Distribution factors</td>
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<td>Communication abilities</td>
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<td>Volunteer engagement</td>
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<td>Security measures</td>
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<td>Preventive maintenance</td>
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<td>Financial impact</td>
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Table 2. Groups Involved in Planning for a Disaster That Would Require a Large Number of Mechanical Ventilators

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<th>Federal</th>
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<td>Department of Homeland Security</td>
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<td>Federal Emergency Management Agency</td>
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<td>Department of Health and Human Services</td>
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<td>Centers for Disease Control and Prevention</td>
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<td>Environmental Protection Agency</td>
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<td>State and Local</td>
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<tr>
<td>Local and state police</td>
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<td>Department of health</td>
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<td>Fire and rescue departments</td>
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<td>Hospitals</td>
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<td>Private</td>
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<td>Professional associations</td>
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<td>Industry representatives</td>
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<td>Physician groups</td>
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<td>Healthcare workforce</td>
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Creating a team and a system for ventilator reserve requires considering the various factors that affect ventilator storage and distribution across a county, region, or state. Public health and hospital representatives, teamed with ventilator physiologists, clinicians, and industry, must work cooperatively to determine the readiness standards, operational plans, inventory creation and management, acquisition standards, security measures, and distribution methods best suited to meet the target capability.

Planning and preparedness efforts extend beyond first responders and receivers. Many of these bring different perspectives and authority to the table. Table 2 shows some of the groups cooperatively engaged in planning, funding, and responding to the needs of state emergency management programs.

Federal funding provides the ability to improve disaster response capability. A rough estimate of the cost to double the number of ventilators in the United States, with safe but inexpensive equipment, is $1 billion. Over the past 6 years, grants from the United States Department of Health
and Human Services Health Resources and Services Administration, which is administered through the Office of the Assistant Secretary of Preparedness and Response, have allotted specific dollar amounts to states to enhance the health care system response capability. Health care systems are all aspects of health response in a continuum of pre-hospital and hospital assets. Health Resources and Services Administration grants have made it possible for health care systems to improve mechanical ventilation capability, and care should be taken to consider cost disparity of caching systems versus direct distribution.

The respiratory care profession is in the middle of the planning and debate. Respiratory therapists are assisting agencies at all levels to assure that emergency ventilators are not measured by quantity alone, but also by clinical capabilities, and the respiratory care profession as a whole is taking a leadership role in identifying the correct strategies for dealing with incidents that would create a large number of patients in need of mechanical ventilation and ensuring that the plans reflect current evidence-based mechanical ventilation practices.

**Essential Education**

Federal funding has provided state public health and health care systems the ability to build ventilator reserve capacity, but there is more at stake than just buying the equipment. All the stakeholders need education on mass casualty incident response that is as evidence-based as possible for situations in which health care needs exceed health care resources. The disaster-response system must incorporate staff, equipment, and supplies in a clearly structured, efficient system. Leaders must be educated on the subject and the issues. First responders and receivers must have clinical core competencies in disaster response. Agency partners and public health officials need education on specific functions of hospital-based professionals. Industry partners should provide product-specific training materials specifically designed for disaster scenarios. And citizens need education on realistic expectations about what care to expect in a disaster and how they can (and can’t) assist in the response.

Respiratory therapists must educate themselves on the standards and practices of public health agencies, government offices, other professions, and medical disaster response procedures. Respiratory therapists and their professional associations can help educate other stakeholders on important issues such as mechanical ventilation in a mass-casualty incident and the question of stockpiling versus distributing ventilators. Further education will also assist in identifying the support and logistical issues. The education efforts should engage all stakeholders and work toward building consensus on approach, methods, and a course of action.

**Necessary Equipment**

Most hospitals cannot afford to purchase and maintain a large supply of sophisticated, full-feature ventilators to hold in reserve for mass casualty events. Planning, decision making, and agreeing on an operational approach is difficult, and there are diverse strong opinions on the subject. Best practice and data should substantiate any negotiated settlement. The critical assessment should consider: single or multiple brands and models of ventilator equipment; required features; gas source; dependability and redundancy of power; infection-control factors; available ventilation modes; preventive maintenance requirements; ancillary equipment and supplies needed; equipment evaluation and performance measures; and cost comparison.

A state’s effort to create a ventilator reserve capacity requires subject-matter expertise, identification of best practices and quality care standards, and contingency planning. Many states and countries (eg, Florida, New York, California, Ohio, Canada, and Israel) have examined the complexities of stockpiling ventilators for a mass casualty incident, and their findings can contribute to an informed debate.

To begin, a state needs to know how many ventilators currently exist and are in daily use within its borders. This information can be obtained from the state hospital association, under the auspices of the American Hospital Association.

Next, the following questions need to be addressed:

- Does the state augment ventilator resources during a time of need?
- If so, are the ventilators stockpiled or distributed to hospitals?
- How is this done? Federal funding? Other means?
- What is the process and who is involved?
- Who is making the decisions?
- Have they consulted with respiratory therapists in their state?
- What processes, specifications, and standards determine equipment selection?
- Are issues such as redundant power, gas source, infection control, and preventive maintenance addressed?
- Is a standardized piece of equipment being used?
- What about supplies such as tubing and circuits, suction catheters, and humidification devices?
- Is there consensus on when to use invasive versus non-invasive ventilation?
- Is the state’s respiratory care profession engaged in the process?
The answers to those questions help identify the strengths and opportunities for improvement.

**Distribution Versus Stockpiling**

Is it better to stockpile ventilators at one site and distribute them to disaster sites as needed (the stockpiling strategy), or instead to increase the number of ventilators at all hospitals (the distribution strategy)? The answer might not be the same for every jurisdiction. Many states have created work groups to address the question of distribution versus stockpiling, and respiratory therapists and their professional organizations are participating. Tables 3 and 4 list pros and cons of stockpiling versus distribution. States and their health care partners must determine what is best for their systems. Hospital preparedness grants from the Health Resources and Services Administration and the Department of Homeland Security are the primary resource for funding the acquisition of disaster-response ventilators.

Hospitals typically have enough ventilators to meet everyday demand, but not enough for demand peaks, at which time they rent additional ventilators. The factors in the choice of distribution versus stockpiling include: equal distribution, standardized product selection, funding process and sustainment, education and training, preventive maintenance, hospital resistance and agreements, and distribution schedules. There are several challenging questions to address in planning for mechanical ventilation in a mass casualty scenario:

- If the ventilators are distributed to hospitals, will the ventilators be stored and not used except for a disaster?
- It is not likely that the model/brand of ventilator held in reserve for disaster will be same as the model(s)/brand(s) the hospital regularly uses, so if the ventilators are stored (instead of regularly used) at the hospital, will the hospital staff be familiar with the disaster ventilators and be expert in their use? This same question applies if the ventilators are stockpiled.
- If the disaster ventilators are regularly used (instead of stored) at the hospital, what percentage of them will be immediately ready for use in a disaster?
- If the ventilators are stockpiled, how long will it take to deliver them to the disaster area?
Some jurisdictions have chosen stockpiling. The stockpiling strategy requires working through regional differences, determining and managing the storage location, security measures, access, costs, oversight, accountability, and distribution and (post-disaster) retrieval of the equipment. Stockpiling is more expensive than distribution. Logistical considerations of stockpiling include maintaining the equipment, replacing equipment if it becomes obsolete, end-user training, and distribution/retrieval.6 The most difficult management issues are preventive maintenance and costs. In some highly populated areas stockpiling might be cost-prohibitive.

The challenges are many and the debate is heated. Some states have made progress in working cooperatively with state and federal partners. What is important for everyone to remember is the emergency management imperative, *Do the most good for the most people with the resources available*. In an ideal world, there would be enough ventilators for everyone when needed, but reality forces us to determine contingency plans. The decisions may be unpopular with some, but we must determine the best course of action and remain consistent, which is not easy, and due diligence is imperative.

**Summary**

States must determine how they are going to manage health care surge in a mass casualty incident. Essential resources such as ventilators can be stockpiled or distributed, and there are pros and cons with each option. Understanding the various factors associated with stockpiling versus distribution establishes a foundation of preparedness to meet the perceived needs of a community. Ventilator reserves must be versatile enough to meet the ventilator demands of a mass casualty and/or pandemic event.5 Federal funding has provided a means for hospitals to acquire ventilators, but there continues to be an insufficient number of ventilators available for a worst-case event.

**Discussion**

Muskat: John, thank you. That was excellent and thought-provoking. I have a couple of questions concerning the ventilator, concerning the option of choosing the hospital in-place storage versus the cache approach. Do we know the life expectancy of a ventilator that is going to be used on a daily basis? I’m not sure that the funding mandate that we’ve gotten since 9/11 is going to hold up forever. Are we using up these stockpile ventilators? Why wouldn’t a private hospital, if they are given one of these ventilators by the state, just buy one less of their own, since they get to use it?

Wilgis: Excellent questions. I will start with your first one, and that’s the life expectancy. We have not really looked at how well they’re holding up. That is something that we try to get feedback about from our hospitals. I am fortunate in my role with Florida Hospital Association that I travel all over the state. My role is to work with hospitals on all of this stuff, so I do communicate very well with not-for-profits, for-profits, everyone. And I’ve had mixed reactions. There are some hospitals that have said, “We don’t use them, we hold them in our own little cache room, and we bring them out from time to time.” And I’ve had some hospitals say, “We are just using them for transport.” I’ve had hospitals say they use them every day.

**ACKNOWLEDGMENTS**

Thanks to the American Hospital Association, the Florida Hospital Association, the Florida Department of Health, the American Association for Respiratory Care, the Florida Society for Respiratory Care, the Florida State Working Group Ventilator Task Team, Kris-Tena Albers ARNP CNM MN, Richard Branson MSc RRT FAARC, and Lewis Rubinson MD PhD.

**REFERENCES**

This is a concern to me because of the wear and tear on the units and the issue of its not being available when you would need it in a disaster. So I don’t really have any concrete data on life expectancy. The Uni-Vent 754 has been battle-tested. I would ask you, what do you see in your experience in Iraq with the wear-and-tear issue? I mean, that’s an extreme environment. At least in a hospital it’s a little bit more controlled.

Muskat: In the extreme environment there is definitely wear and tear. The biggest problems have been dust getting into the ventilators and a declining battery half life. The life expectancy for a ventilator in Iraq is somewhere on the order of 2 years. Then it just simply gets turned into the warehouse and we never see it again. So that clearly is an issue, and I think that if you adopt the strategy of giving it to the hospitals, that’s a question that not only needs to be investigated, but really giving a clearer set of understanding to the hospitals and say, look if we’re going to give it to you, you need to set it aside but maintain it. I think if you don’t, you’re going to run the risk that when we really need it 5–10 years from now, it won’t be available.

Wilgis: We have had hospitals come back to us and ask if they can spend their HRSA [Health Resources and Services Administration] funds on preventive maintenance and not ventilator purchase. One thing hospitals have had to replace is batteries. That has been a real issue for them. And your second question was. . . ?

Muskat: If the hospital is given one, why would they just not buy another one of their own, particularly if they are encouraged to use the gift ventilator. In a cost-conscious environment, hospitals are cutting corners wherever they can.

Wilgis: Again, hospitals are all over the board. We have some that do that and they’re very grateful, especially some of our smaller, rural hospitals where they might have 5 ventilators in their whole fleet. Now we’re giving them a couple to embellish their stockpile internally. We have other facilities that take their money and buy the top-of-the-line ICU [intensive care unit] ventilator, not thinking about a surge event. So, again, it comes down to the fact that we can only recommend what we think is appropriate. Hospitals can then choose what they want autonomously. It has been a challenge, and I think education about the process and planning essentials is key.

Rubinson: Do you have an ideal formula in Florida for distribution? Because I saw on your pros-and-cons slide you actually put delivery time is longer when you cache ventilators centrally. Obviously, if it’s a spread-out event, then that may be true. But if they’re regionally cached you don’t have to go to each hospital and take ventilators away. So the other thing is the ratio; right now what I’m seeing is that if you bought 800 ventilators, while a big number, in total if they are all distributed evenly, that is less than 4 per hospital in Florida.

Wilgis: Let me start with your first question. We do have a mechanism for distribution. It started with one region that was caching. This was the northeast Florida region, and they were holding everything back. They had a pretty good formula of how they were going to send the units out to about 20 hospitals. The state department of health worked with individual counties to develop this process, and the counties controlled the distribution. A state-wide distribution plan or a formula is addressed through mutual aid and emergency management planning.

Florida statute describes the premise of how to respond and a sequence of events. The process begins with a declaration from the governor and goes from there. That’s why I was interested in your comments yesterday about hospitals declaring disaster to their county EOCs [emergency operations centers] and going the other way. Your second question was. . . ?

Rubinson: Obviously, there are pros and cons, which you set out, but even if you bought 2,000 ventilators, if you distributed all of those out, that is still less than 10 per hospital.

Wilgis: Agreed. This is where it gets complex. Florida uses what they call Regional Health and Medical Co-Chairs. These are folks who work with the department of health. Three are physicians, one is a nurse, the others are county or county health department officials. These folks are charged with making decisions for their entire region. So, they select the hospitals that are funded. We know that we can’t purchase enough ventilators for every hospital every year. The co-chairs herd the cats. Their role involves deciding which hospitals have the biggest gaps and which need the most support.

They started with our large trauma centers first and our large urban hospitals (where probably the most number of casualties would go to) and then they worked from there. Now we are looking at the gaps of other facilities, like our rural hospitals. The Regional Co-Chairs have a role in deciding how vents get distributed. Hospitals work with a Regional Hospital Coordinator who makes sure the process comes together and that hospitals live up to the language of the grant and all of that. It’s really a complex system to learn to work within, and any of these roles can, and do, change.

Talmor: You mentioned sole-sourcing for ventilator purchasing. That is something that really concerns me and something that we’ve actually decided against in Massachusetts. It is worrying when a country the size of Canada decides on one ventilator, the Newport, which is essentially a ven-
tilator at the end of its development cycle. I see that happening in many places around the United States. Ventilators like the Uni-Vent 754, like the Newport, like the LTV 1200; all of these are 15-year-old ventilators that are being purchased in mass quantities. You open yourself up to problems; if there’s a recall or if there are breakdowns, you are really losing capacity. For that reason, in Boston at least, or Massachusetts more correctly, we have decided to go with at least 2 ventilator types. I was wondering if you could comment further on that or if anybody else here could comment on that?

Branson: In Ohio the decision was made to go 50/50, so that if they did have one ventilator go down because of recalls, they would in fact not lose all of their capacity, and I think that’s based on the CDC [Centers for Disease Control and Prevention] thinking as well—that if you have half and half, you won’t all be wiped out by a single component failure or loss, although that adds to your education requirement because now you have to teach people how to use 2 ventilators, not just one. Every issue we bring up here has advantages and disadvantages as well. At present we are all speculating, because we have not tested the system.

Muskat: On the other hand, if you take a ventilator that’s near the end of its development cycle, then you’re going to get a ventilator that has been presumably tried and true for a number of years, so the likelihood of a recall is less likely. So, again, the trade off is that you have 2 ventilators that have 2 completely different systems, 2 circuit systems and so forth. The CDC’s example with its 2 different ventilators, their different storage requirements and so forth, is a good example of what happens when you have 2 different items serving the same purpose.

The military made the choice to use the Uni-Vent 754 not only for the Air Force critical care teams but also did so for all of the field hospitals. Everybody used the same ventilators, so the transfer of patients became very seamless, so that you could literally change one circuit to the next and all you did was keep moving the ventilator back and forth. I would throw out that idea as a counter-argument to the idea of splitting.

Wilgis: I would just like to add some comments. In Florida we served as a group of subject-matter experts to the state. Uni-Vent 754 was already in the game. They had secured a contract for all ventilator purchase through HRSA funding for the state. At the time, Florida’s funding went to purchase Uni-Vent 754s for hospitals. They were used widely in the military, they had air-worthiness through certification through DOD [Department of Defense]. We looked for standardization and an easy way to educate everyone. We worked very closely with that manufacturer and our state representatives to help achieve all of that. We developed a list of standards and specifications, starting with CDC criteria, and made the list very detailed. Some of the input influencing our decisions came from hospitals. Hospitals were saying, “We don’t want that product, we want to look at something else,” and that is why we opened up and went away from a sole provider.

Talmor: I would like to make a comment semi-related to this. While these transport type ventilators have been around for many years and are well-tested in the scenarios that they have been used in, the scenarios that they have been used in up to now aren’t really avian influenza pandemics. They’re being used as transport ventilators or for short-term ventilator management of young people with extremity injuries in Iraq.

So, again, we have a lot of unknowns as to the abilities of these ventilators to actually support patients who are sick with ARDS [acute respiratory distress syndrome]-like symptoms of avian influenza. There’s been good work done by several people, some of them at this table, but I think we still have more unknowns than knowns on that.

Branson: I’m not in the military—but the injuries in Iraq from the improvised explosive devices are a combination of blast, massive blood loss, tissue destruction, reperfusion injury after massive transfusion, and with acute respiratory failure. These patients are on up to 20 cm H2O PEEP [positive end-expiratory pressure] and are ventilated successfully from Balad to Landstuhl. You don’t need a $30,000 ventilator for all these patients. It’s just what we do because we have that luxury here in the United States. If you were stuck, you could go back and use an MA1 on lots of patients and be very successful. Just because we have this standard where we have to have the most expensive, most bells-and-whistles and most modes, none of which have any evidence that they are any better.

A host of portable ventilators usually thought of as transport, home-care, subacute-care ventilators could be successfully used to ventilate sick patients in the ICU. Just because we use them for only short periods of time, there is no evidence that suggests that they wouldn’t continue to support oxygenation and ventilation for a longer period of time. I am not suggesting that these portable devices do not have limitations; clearly they do, but it seems that they provide the best alternative when you combine price, size, and performance.

Muskat: The Injury Severity Score for an injured soldier currently in Iraq is 25, which far exceeds any patient in our standard trauma centers today, which on average is around 15. Additionally, we provide care for a number of Iraqi patients.
who remain in the field hospital for several days to a week or more on a Uni-Vent 754 ventilator. So I would argue that in the last 5 years we have really stressed the Uni-Vent 754 and figured out what it can and can’t do. There are clearly pulmonary cripples that we have taken care of that exceed the capability of the ventilator; however, those numbers are fairly small. So I’m not putting a plug in for the Uni-Vent 754; I’m just saying that we need to pick a ventilator that is relatively cheap, small, and includes all of the things that we talked about yesterday.