Inpatient Chronic Assisted Ventilatory Care*
A 15-Year Experience

Peter J. Wijkstra, MD; Monica A. Avendaño, MD, FCCP; and Roger S. Goldstein, MB, ChB, FCCP

Study objectives: Ventilator users who are unable to leave the acute care setting may be transferred to a unit for chronic assisted ventilatory care (CAVC) with the goal of optimizing their level of function. In this report, we summarize the outcomes of all patients admitted to a CAVC unit between 1986 and 2001.

Patients and methods: Fifty patients (24 with neuromuscular disease [NMD], 10 with spinal cord injury [SCI], 7 with thoracic restriction [TR], 7 with COPD, and 2 with parenchymal restriction [PR]) were reviewed. Thirty-eight patients were transferred to the CAVC unit from intensive care, 5 patients were transferred from inpatient respiratory rehabilitation, 4 patients came from home, and 3 patients came from pediatric long-term care. At the time of CAVC unit admission, all patients were receiving mechanical ventilation via a tracheostomy tube.

Results: Ventilator time increased gradually in patients with COPD from 16 h (SD, 5.6) to 22.9 h (SD, 3.0) per day (p < 0.05), and in patients with TR from 18.9 h (SD, 6.1) to 22.9 h (SD, 4.5) [not significant]. Five of the 10 patients with SCI were decannulated. Functional mobility, which decreased in patients with COPD and patients with TR, remained stable in NMD and PR and improved in SCI. Eighteen patients returned home or to an attendant care facility (COPD, n = 1; NMD, n = 10; SCI, n = 5; PR, n = 2); 11 patients died in the CAVC unit (COPD, n = 6; TR, n = 3; NMD, n = 1; SCI, n = 1); and 7 patients were transferred to intensive care, where they died. The average direct cost per patient per diem increased from $252 (Canadian) in 1988 to $335 in 2001.

Conclusion: A CAVC unit can provide a safe environment for severely impaired, ventilator-dependent individuals, many of whom (36%) left for a more independent community-based environment. Better outcomes were seen among patients with SCI and NMD than in patients with COPD and TR.

(CHEST 2003; 124:850–856)

Key words: chronic assisted ventilatory care; COPD; mechanical ventilation; outcomes

Abbreviations: CAVC = chronic assisted ventilatory care; NMD = neuromuscular disease; PR = parenchymal restriction; SCI = spinal cord injury; TR = thoracic restriction

M any individuals receive mechanical ventilatory support as a result of medical illness or trauma in which ventilatory reserve is compromised. Most are weaned promptly as they recover. A small number of patients become clinically stable but remain ventilator dependent. If for either medical or psychosocial reasons such patients are not able to return to the community, they are usually obliged to remain in the ICU, especially if they have minimal ventilator-free time and poor functional mobility. For them, the ICU, lacking any rehabilitative focus, is not an ideal environment.1–5 They may actually be neglected in favor of the more immediate needs of those who are acutely ill.

Improved functional capability, however, might be accomplished after prolonged slow rehabilitation in a chronic assisted ventilatory care (CAVC) unit. The CAVC unit is intended for eligible ventilator-dependent individuals who required transfer to an environment in which they could remain permanently or undergo a gradual process of rehabilitation followed by reintegration into the community. The presence of a CAVC unit contributes to the spectrum of care available for individuals with respiratory failure who...
may benefit from rehabilitation and home-ventilation training. In addition to admitting patients from other medical centers, the CAVC unit is a resource facility for ventilator-assisted individuals living at home in whom a change in their medical or social circumstances means that they can no longer live independently.

In this report, we describe our experience with a CAVC unit initiated 15 years ago to provide patients who required ongoing ventilatory support with a safe inpatient environment outside of the acute care setting. The goal of management was always to improve functional ability within a rehabilitative environment. Eighteen individuals (36%) have been able to return to the community.

**Materials and Methods**

The CAVC Unit

The CAVC unit is located in a rehabilitation and complex continuing care hospital. Patients are referred to this unit if they become stable but cannot be weaned from the ventilator. Initial funding in 1986 from the provincial Ministry of Health was for a 10-bed unit, which was expanded to 14 beds in 1992. Since its inception, the unit has remained fully occupied. The clinical program is led by respirologists and staffed by a multidisciplinary health-care team that includes or has access to the following: nursing, respiratory therapy, physical therapy, occupational therapy, social work, psychology, clinical dietician, and speech language pathology. Referring physicians provide a written medical summary. Potential patients are assessed at the referring center by a respirologist and representative members of the health-care team.

Admission criteria require that those admitted be mentally alert and clinically stable for at least 2 weeks. Patients must have recognized the need for long-term ventilation and be motivated to achieve improved function. Patients who are unstable or who require intensive nursing such as very frequent suctioning, to achieve improved function. Patients who are unstable or who required ongoing ventilatory support with a safe inpatient environment outside of the acute care setting. The goal of management was always to improve functional ability within a rehabilitative environment. Eighteen individuals (36%) have been able to return to the community.

**Data Collection**

Two respirologists (P.J.W., M.A.A.) reviewed the charts of all patients admitted to the CAVC unit between December 1986 and December 2001. The information retrieved included the following: (1) on CAVC unit admission: age, sex, diagnosis, date of admission to the CAVC unit, location of the patient at the time of the referral, waiting time prior to admission to the CAVC unit, length of time during which the patient received mechanical support prior to the CAVC application, and modality of ventilation and daily ventilatory time; (2) while in the CAVC unit: level of functional mobility, ie, walking, wheelchair, or bedridden; any changes in ventilatory support (invasive, noninvasive, decannulation); ventilator time; respiratory and nonrespiratory complications; and reasons for transfer to acute care; and (3) discharge data: length of stay, location to which patient was discharged, reason for discharge, and reason for death.

**Statistics**

Changes in ventilation time within each category were analyzed using Student t test.

**Results**

**Patient Demographics**

Fifty patients (32 men and 18 women; mean age, 46 years; range, 18 to 76 years) were admitted to the CAVC unit between 1986 and 2001. They were categorized by primary diagnosis into obstructive (COPD) and nonobstructive conditions. The latter was subclassified into four groups: neuromuscular disease (NMD), spinal cord injury (SCI) [C1-C2, seven patients; C3-C4, two patients; and C6, one patient], thoracic restriction (TR), and parenchymal restriction (PR). The number of patients in each of these groups is shown in Table 1.

The 24 patients with NMD included the following: Becker dystrophy (n = 1), Duchenne muscular dystrophy (n = 6), amyotrophic lateral sclerosis (n = 3), postencephalitis cerebral palsy (n = 1), brainstem vascular accident (n = 1), high spinal cord astrocy-

**Table 1—Demographics of Patients Admitted Between 1986 and 2000**

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Patients, No.</th>
<th>Male/Female Sex, No.</th>
<th>Age, yr (SD)</th>
<th>Duration of Mechanical Ventilation, (Range), mo Admitted From</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obstructive (COPD)</td>
<td>7</td>
<td>4/3</td>
<td>66.5 (8.5)</td>
<td>At Home 3.4 (2.5–111) [n = 4] In Hospital 5.6 (0.5–9) ICU (n = 7)</td>
</tr>
<tr>
<td>Nonobstructive NMD</td>
<td>24</td>
<td>16/8</td>
<td>40.1 (17.1)</td>
<td>SCI 23.4 (54–180) [n = 5] ICU (n = 15)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Home (n = 3) Rehabilitation unit (n = 3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Children’s hospital (n = 3) 16.3 (0–132)</td>
</tr>
<tr>
<td>SCI</td>
<td>10</td>
<td>7/3</td>
<td>39.2 (19.2)</td>
<td>ICU (n = 10)</td>
</tr>
<tr>
<td>TR</td>
<td>7</td>
<td>4/3</td>
<td>61.4 (10.9)</td>
<td>SCI 25.9 (12–83) [n = 4] ICU (n = 5)</td>
</tr>
<tr>
<td>PR</td>
<td>2</td>
<td>1/1</td>
<td>46.5 (4.9)</td>
<td>SCI 5.3 (0–10) ICU (n = 1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rehabilitation unit (n = 1)</td>
</tr>
</tbody>
</table>

toma (n = 1), idiopathic motor neuropathy (n = 1), C5-C6 subluxation from rheumatoid arthritis (n = 1), myotonic dystrophy (n = 1), multiple sclerosis (n = 1), postpoliomyelitis (n = 2), degenerative neuromuscular disease (n = 3), scleroderma (n = 1), and transverse myelitis (n = 1).

Patients with TR included those with kyphoscoliosis (n = 6) and post-remote pneumonectomy (n = 1). The group with PR included one patient after ARDS and one patient with idiopathic pulmonary fibrosis.

**CACV Unit Admissions**

Most patients (76%) were admitted directly from the ICU. The waiting time in the ICU before transfer for CAVC varied widely (Table 1). The duration of ventilatory support prior to the application for CAVC differed among the diagnostic categories. Whereas patients with COPD received mechanical ventilation for 9 months (range, 5 to 14 months), those with NMD received mechanical ventilation for almost 40 months (range, 0 to 180 months) prior to applying for CAVC. Patients with SCI received mechanical ventilation for 12 months (range, 2 to 36 months), and those with TR received mechanical ventilation for 91 months (range, 6 to 420 months).

At the time of CAVC unit admission, all patients were receiving mechanical ventilation via a tracheostomy. Subsequently, seven patients were decannulated: five patients before discharge (14.2 months after CAVC unit admission; range, 3 to 48 months), and two patients at 6 months and 7 months, respectively, following discharge. Patients who were decannulated came mainly from the group with SCI, in which two patients were converted to noninvasive positive pressure ventilation, one patient was converted to diaphragmatic pacing, and two patients were completely weaned 7 months after starting ventilation. An additional patient with PR became ventilator independent 22 months after starting mechanical ventilation.

**Ventilator Time**

Ventilator-free time differed among the diagnostic categories. Patients with COPD and those with TR increased their ventilator requirements: COPD, 16 h (SD, 5.6) to 22.9 h (SD, 3.0) [p < 0.05]; TR, 18.9 h (SD, 6.1) to 22.9 h (SD, 4.5) [p = 0.61]. Ventilatory requirements for patients with NMD remained constant (20.9 h [SD, 5.1] to 19.0 h [SD, 6.2]; p = 0.56), whereas it decreased in patients with SCI (20.8 h [SD 3.8] to 13.6 h [SD, 9.8]; p < 0.05) and in both patients with PR (18.0 h [SD, 5.5] to 12.0 h [SD, 17]).

**Mobility**

Functional mobility diminished gradually in patients with COPD. On CAVC unit admission, five patients were ambulatory and two patients were wheelchair assisted. Eventually, six patients became immobile and bedridden, unable to transfer independently to a wheelchair. On CAVC unit admission, four patients with TR were ambulatory, whereas at discharge only two patients could walk. Functional mobility could be improved in patients with SCI by using power wheelchair assistance. On CAVC unit admission, five patients were using wheelchairs (of whom four patients were functionally mobile) and five patients were bedridden. At the time of discharge, seven patients were functionally mobile with power wheelchair assistance, one patient was walking, and only two patients remained bedridden (Table 2).

**Complications**

Complications are summarized in Table 3. The most common associated condition was depression, for which 15 patients required antidepressants. Severe urinary tract infections were identified in eight patients, four of whom required transfer to the ICU. Another six patients were transferred to the ICU: hemoptysis (n = 2), GI bleed (n = 1), central line for antibiotics (n = 1), unstable diabetes (n = 1), and abdominal problems (n = 1). Of those transferred, three patients returned for CAVC. Surgery was required in two patients (removal of a thymoma and debridement of an ischial pressure sore, respectively).

**Length of Stay**

The mean length of stay (excluding those currently in the CAVC unit) varied widely. For patients with COPD, it was 27 months (range, 2 to 56 months); for patients with NMD, it was 26 months (range, 1.5 to 120 months). Patients with SCI stayed 26 months (range, 0.5 to 96 months), and those with TR stayed 85 months (range, 1 to 186 months). Table 3 also includes the details of discharge from the CAVC unit. Of note, six of the seven patients with COPD died in the CAVC unit, with only one patient returning to the community. Ten patients with NMD underwent rehabilitation and subsequently returned to the community either directly from the CAVC unit (n = 6) or following placement in a transitional living environment (n = 4). Only one patient with NMD died in the CAVC unit, although three others died following transfer to the ICU. Five patients with SCI returned home or to an attendant care facility: two patients directly from the CAVC unit, and three...
others after a short period in a transitional living environment. Five patients with TR died (three patients in the CVC unit, and two patients soon after transfer to the ICU with hemoptysis). Both patients with PR returned home.

**Costs**

Costs were calculated for the total unit and then divided by the number of beds. From 1987 to 1988 (10-bed unit), the annual direct costs per bed (all costs in Canadian dollars) totaled $92,000, which translates to a per bed, per diem cost of $252.00. From 2000 to 2001 (14-bed unit), the annual direct costs per bed had risen to $122,412, which translates to a per bed, per diem cost of $335.00. This 33% increase was attributable primarily to 27% increase in staff salaries ($870,339 for the 10-bed unit to $1,546,356 for the 14-bed unit), and an increase of 197% in medical equipment plus supplies ($35,800 for the 10-bed unit to $149,339 for the 14-bed unit). The current per bed, per diem direct cost of $335.00 does not include any overhead costs such as maintenance, administration, or food services, which together are responsible for an additional $150 per bed per diem.

**Discussion**

The CAVC unit provides a safe alternative for severely impaired, ventilator-dependent individuals, with the goal of achieving improved functional ability. Although at the time of referral, patients were extremely impaired, disabled, and handicapped, many did return to the community after prolonged rehabilitation. Most patients (76%) came from the ICU. Those who came from home often reflected a failure of the home support system (eg, loss of a critical caregiver, insufficient home support) and therefore did not usually return to the home. Three patients were completely weaned from ventilatory support: two patient with SCI at C5 after 7 months, and one patient with PR following ARDS after 22 months of mechanical ventilation. Those who remained in the CAVC unit were encouraged to move toward their potential in terms of mobility, functional activities, and self-directed care.

The overall complication rate was low given the level of impairment of the CAVC population, many of whom had progressive underlying conditions and had experienced protracted periods of hospitalization in the ICU before their transfer to the CAVC unit. Of note, the lengthy ICU stay did not reflect the need for ongoing intensive care, so much as the waiting time for admission for CAVC, as in most Ontario hospitals, patients receiving invasive mechanical ventilation are not managed in a general medical ward. Only 10 patients required transfer back to the ICU, from which 4 patients returned. The most common complication was depression, which occurred among those with progressive underlying disorders and among the previously healthy younger individuals who sustained severe trauma (SCI). The next most common complication was severe urinary tract infection, diagnosed in eight patients (16%), four of whom subsequently acquired generalized sepsis requiring transfer to the ICU, and only one of whom survived. Considering that all

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Admission</th>
<th>Discharge</th>
<th>Admission</th>
<th>Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obstructive (COPD)</td>
<td>16 (5.6)</td>
<td>22.9 (3.0)</td>
<td>Walking (n = 5)</td>
<td>Walking (n = 1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wheelchair (n = 2)</td>
<td>Bedridden (n = 6)</td>
</tr>
<tr>
<td>Nonobstructive</td>
<td>20.9 (5.1)</td>
<td>19 (6.2)</td>
<td>Walking (n = 4)</td>
<td>Walking (n = 4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wheelchair (14 of 20)</td>
<td>Wheelchair (19 of 19)</td>
</tr>
<tr>
<td>SCI</td>
<td>20.8 (3.8)</td>
<td>13.6 (9.8)</td>
<td>Walking (n = 1)</td>
<td>Wheelchair (7 of 7)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bedridden (n = 5)</td>
<td>Bedridden (n = 2)</td>
</tr>
<tr>
<td>TR</td>
<td>18.9 (6.1)</td>
<td>22.9 (4.5)</td>
<td>Walking (n = 4)</td>
<td>Walking (n = 2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wheelchair (n = 2)</td>
<td>Wheelchair (1 of 1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bedridden (n = 1)</td>
<td>Bedridden (n = 4)</td>
</tr>
<tr>
<td>PR</td>
<td>18.0 (8.5)</td>
<td>12.0 (17)</td>
<td>Walking (n = 1)</td>
<td>Wheelchair (n = 1)</td>
</tr>
</tbody>
</table>

*Data are presented as mean (SD) unless otherwise indicated.

* Decannulation in five patients (noninvasive positive pressure ventilation \(n = 2\), diaphragm pacers \(n = 1\), weaned \(n = 2\)).

§ One patient weaned.
patients with SCI and some patients with NMD required indwelling urinary catheters, this complication was not surprising.

Patients with SCI seem to have benefited the most from their stay in the CAVC unit. Evaluation of respiratory reserve together with regular noninvasive monitoring of gas exchange has enabled most to increase their ventilator-free time. Subsequently, several patients have been decannulated while in the CAVC unit or shortly after their discharge to the community. Similar outcomes for patients with SCI have been reported from larger series of patients, many of whom progressed from cuffed to uncuffed tracheostomy tubes, noninvasive ventilation, or complete decannulation.6–9 Functional mobility could be improved with power wheelchair use to the point of most patients being able to move freely around the hospital grounds.

Patients with NMD also did well, reflected by almost half being able to leave the unit for home or an attendant care facility. Those who remained in the CAVC unit often did so because of their psychosocial condition rather than their physical condition. Although noninvasive ventilation is feasible over prolonged periods in patients with NMD,3–5 as their underlying condition progresses some patients will require a tracheostomy for airway protection. Leger and colleagues2 followed up a large group of patients with chronic respiratory insufficiency, which in 16 subjects was attributable to NMD. The authors reported two deaths over a 5-year period, and a further five subjects who were converted to invasive ventilation following an episode of acute respiratory failure. In contrast, many of our patients were admitted following prolonged invasive ventilation for respiratory failure when it became clear that they could not be discharged to the community. Our patients were highly selected from among the more impaired individuals, similar to those reported from a community-based, regional ventilator weaning unit by Bagley and Cooney,10 who noted that only 22% could be weaned following invasive ventilation.

Table 3—CAVC Outcomes

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Complications</th>
<th>Mean Length of Stay (Range), mo</th>
<th>Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obstructive (COPD)</td>
<td>Depression (n = 4)</td>
<td>27.2 (2–56)</td>
<td>Died (n = 6) [disease progression] Home (n = 1)</td>
</tr>
<tr>
<td>Nonobstructive NMD</td>
<td>Arrhythmia (n = 1) Urinary tract infection (n = 2) Urinary sepsis (n = 2) to ICU Ischial pressure sore to surgery GI bleeding (n = 1) to ICU* Hemothysis (n = 1) to ICU* Gastric atony, vomiting (n = 1) to ICU Obesity (n = 1) Renal-cell carcinoma (n = 1) Thyroid (n = 1) to surgery Depression (n = 5)</td>
<td>26 (1.5–120)</td>
<td>CAVC (n = 10) current Home (n = 10) Rehabilitation (n = 4) Died ICU (n = 3) [sepsis (n = 2), abdominal pain (n = 1)] Died CAVC (n = 1) [disease progression]</td>
</tr>
<tr>
<td>SCI</td>
<td>Seizures (n = 2) Urinary tract infection (n = 2) Urinary sepsis (n = 2) to ICU† Central line (n = 1) to ICU* Depression (n = 5) Instability of diabetes mellitus to ICU</td>
<td>26.4 (0.5–96)</td>
<td>CAVC (n = 2) current Home (n = 2) Died (n = 1) disease progression Transitional community living (n = 3) Died ICU (n = 3) [sepsis (n = 2), diabetes (n = 1)]</td>
</tr>
<tr>
<td>TR</td>
<td>Cirrhosis (n = 1) GI bleeding (n = 1) Cerebrovascular accident (n = 1) Glaucoma (n = 1) Coronary artery disease (n = 1) Prostatic cancer (n = 1) Hemothysis (n = 1) to ICU Depression (n = 4)</td>
<td>84.6 (1–186)</td>
<td>CAVC (n = 2) current Died CAVC (n = 3) disease progression Died ICU (n = 2) hemothysis</td>
</tr>
<tr>
<td>PR</td>
<td>None</td>
<td>9 (2–16)</td>
<td>Home (n = 2)</td>
</tr>
</tbody>
</table>

*Returned to CAVC.
†One patient remained and one patient returned.
‡In patients discharged from the CAVC unit (excluded patients who are still receiving CAVC).
Patients with TR also deteriorated slowly, likely as a result of their associated medical conditions. Most patients with TR who progress to respiratory failure can be effectively managed at home while receiving nocturnal noninvasive positive pressure ventilation,\textsuperscript{2,3,5} with few discontinuing because of death or acute respiratory failure.\textsuperscript{2} Those who require inpatient management in a CAVC unit represent the more severely impaired, disabled, and handicapped patients, many of whom have associated medical conditions such as pulmonary parenchymal, GI, cardiovascular, and endocrine diseases. There is limited information regarding the clinical progress of patients with TR following their requiring invasive ventilation.\textsuperscript{11–13}

Patients with COPD continued to deteriorate, increasing their ventilator dependence and decreasing their functional mobility, in keeping with the continued progression of the underlying primary disorder. Although noninvasive ventilation, or brief periods of invasive ventilation during acute respiratory failure, may be valuable,\textsuperscript{4,14,15} the role of ongoing ventilation in COPD remains unclear, with most clinicians avoiding a situation of ongoing invasive ventilation, most studies\textsuperscript{16–18} of elective noninvasive ventilation being negative or equivocal. Inevitably, some patients proceed to invasive ventilation after which they present as difficult to wean. COPD has been noted to be a frequent cause or contributor to ventilator dependency,\textsuperscript{10,13,19} therefore, our clinical observations were not unexpected. Our patients with COPD were also older than the other diagnostic categories of patients on the CAVC unit, and all had comorbidities such as coronary artery disease even though the primary cause of death was attributed to progression of respiratory disease.

A CAVC unit represents a less expensive option (485.00/d) than an ICU ($1,850/d)\textsuperscript{20} for patients who are medically stable but remain ventilator dependent. According to the Ontario Ministry of Health and Long Term Care Area Office for Attendant Care Facilities, a further cost reduction occurred for those patients transferred from the CAVC unit to an attendant care facility (direct cost, $345/d) [Laura Forma, BSc; personal communication; 2002]. The costs, as in all institutions, were largely determined by staff salaries as well as staff-to-patient ratios. The CAVC unit, while providing appropriate care, clearly does not require the nursing staff-to-patient ratios essential for the ICU. Although the rehabilitative environment employs more physical and occupational therapists, the staff mix is able to utilize nursing assistants, rehabilitation support staff, and others with more basic clinical skills who work as part of the rehabilitation team. Although the CAVC unit does represent a substantial resource outlay for a continuing care rehabilitation center, important benefits to having a centralized unit include economies of scale in resource utilization and in staff expertise, as well as providing a more appropriate environment for the patients.

The CAVC unit represents a challenging clinical environment for the health-care professional. Physicians work closely with respiratory therapists, nurses, physical therapists, and occupational therapists to develop an invaluable expertise in addressing the clinical and psychosocial requirements of long-term ventilator-dependent individuals. Despite their substantial impairments and extensive prior hospitalization, some patients requiring CAVC are able to return to the community. Others benefit from a rehabilitative environment that promotes self-directed care and improved functional ability.

\textbf{References}

17 Meecham Jones DJ, Paul EA, Jones PW. Nasal pressure support ventilation plus oxygen compared with oxygen therapy alone in hypercapnic COPD. AJR Am J Roentgenol 1995; 152:538–544
18 Rossi A, Hill NS. Noninvasive ventilation has (not) been shown to be ineffective in stable COPD: pro/con editorial. Am J Respir Crit Care Med 2000; 161:688–691