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Pediatr Pulmonol. Author manuscript; available in PMC 2013 June 27.

Published in final edited form as:
Pediatr Pulmonol. 2012 April ; 47(4): 409–414. doi:10.1002/ppul.21536.

Hospital Readmissions for Newly Discharged Pediatric Home Mechanical Ventilation Patients

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Summary

Background—Ventilator-dependent children have complex chronic conditions that put them at risk for acute illness and repeated hospitalizations.

Objectives—To determine the 12-month incidence of and risk factors for non-elective readmission in children with chronic respiratory failure (CRF) after initiation on home mechanical ventilation (HMV) via tracheostomy.

Methods—A retrospective cohort study of 109 HMV patients initiated and followed at an university-affiliated children's hospital between 2003 and 2009. Patient characteristics are presented using descriptive statistics; generalized estimated equations are used to estimate adjusted odds ratios of select predictor variables for readmission.

Results—The 12-month incidence of non-elective readmission was 40%. Close to half of these readmissions occurred within the first 3 months post-index discharge. Pneumonia and tracheitis were the most common reasons for readmission; 64% were pulmonary- or tracheostomy-related. Most demographic and clinical patient characteristics were not statistically associated with non-elective readmissions. Although, a change in the child's management within 7 days before discharge was associated readmissions shortly after index discharge.

Conclusion—Non-elective readmissions of newly initiated pediatric HMV patients were common and likely multifactorial. Many of these readmissions were airway-related, and some may have been potentially preventable.

Keywords

readmission; home mechanical ventilation; tracheostomy; child

INTRODUCTION

Unplanned readmission is an important clinical outcome, both to patients and the healthcare system. Given their medical fragility, children with complex chronic conditions are at risk for repeated acute illness and hospitalization.[1,2] Children with chronic respiratory failure (CRF) who are dependent on positive-pressure ventilation via tracheostomy fall within this group. Earlier studies have commented on the readmissions of ventilator- dependent children.[3–8] However, these studies pooled these children with other patient populations,

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such as those on supplemental oxygenation or non-invasive ventilation and those with tracheostomy without ventilator support, examined readmissions to pulmonary rehabilitation facilities as opposed to acute care hospitals, or did not explore the possible risk factors for readmissions.

Children's Hospital Los Angeles (CHLA) has followed children on home mechanical ventilation (HMV) for over 33 years.[9] Our anecdotal experience was that our patients were frequently readmitted for non-elective reasons and often shortly after initial discharge. Thus, in order to better understand the reasons for, pattern of, and factors associated with these readmissions, we conducted a retrospective analysis of our patients initiated on HMV via tracheostomy between 2003 and 2009. Understanding the factors associated with readmissions in children on HMV can lead to focused efforts to decrease their incidence and therefore the burden of disease on children, families, and the healthcare system.

METHODS

We conducted a retrospective cohort study of all HMV via tracheostomy patients who were initiated at CHLA between January 2003 and October 2009, in order to examine their non-elective readmissions to our hospital. Patients were identified from a list of all HMV patients that is prospectively maintained by the program coordinator (SSK). Patients who were initiated at other institutions or were over 21 years of age at initiation were excluded. Patient data and readmission outcomes were extracted by chart review from the Pediatric Intensive Care Unit database (Microsoft Access © Microsoft Corporation, Redmond, WA) and the hospital's electronic medical record (Knowledge, Information, Decision Support © Cerner Corporation, Kansas City, MO). Reasons for non-elective readmissions were extracted from the attending physician's admission note. Seasonality of these readmissions was also described.

Data was collected on patients' gender, race/ethnicity, age at initiation of HMV, comorbidities at the time of initiation, insurance type (private or public), and, for those that resided at home, whether they received any regular professional home care. Comorbidities described included cerebral palsy, chromosomal anomalies or genetic abnormality, congenital heart disease (both corrected and not), neurodevelopmental delay resulting in the need for assistance for activities of daily living, epilepsy, history of prematurity (<37 weeks gestation), and feeding tube or ventricular shunt dependence. Professional home care was defined as services provided by paid, non-family, licensed persons (e.g., registered nurses and licensed vocational nurses). All HMV patients qualified for 16 hr per day of home care. However, rarely could this number of hours be provided, and our patients who did receive home care services averaged 98–112 hr every 2 weeks. Some patients received no professional home care services for various reasons, ranging from family choice to there being no home care agencies in their area that provided such services.

Data was also collected on each patient's primary cause of CRF and indication for HMV, type of home ventilator used, hours of ventilator dependence, place of residence (home or sub-acute facility), and the number of post-initiation CHLA Pulmonology clinic visits. CRF was defined as full or part-time ventilator dependence after repeated, failed attempts to wean from assisted ventilation in a person without superimposed acute respiratory disease. Causes of CRF were classified into three subgroups: chronic pulmonary diseases (CPD), ventilatory muscle weakness (VMW), and central hypoventilation syndromes (CHS).[10] Home ventilator type was grouped into continuous flow (predominately Newport HT-50 [Newport Medical Instruments, Costa Mesa, CA], but also Pneumonetic LTV series [CareFusion, San Diego, CA], and TBird Legacy [VIASYS Healthcare, Inc, Conshohocken, PA] ventilators) or non-continuous flow (Aequitron LP10 [Puritan Bennett, Boulder, CO]). Patients covered by

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public insurance programs were placed initially on non-continuous flow ventilators. Reimbursement rules only allowed for transition to a continuous flow ventilators if a patient's clinical status, oxygenation saturation, or partial pressure of carbon dioxide were not appropriate on a LP10. Most private insurances covered both types of ventilators. Hours of ventilator dependence were grouped into fulltime (≥16 hr/day of ventilator use) and part-time (<16 hr/day). We also noted whether there was a significant change in a child's management—defined as an increase in ventilator settings or fraction of inspired oxygen, an addition of a new medication, or changes in feeding regimen without demonstration of consistent tolerance—within 7 days prior to initial discharge. The lengths of hospital stay for index admission (i.e., when HMV was initiated) were collected, as was the total lengths of stay (LOS) for readmissions in the subsequent year. Patients were categorized into those who had a non-elective readmission and those that did not and were compared across these characteristics using Pearson's chi-square test, two-tailed Fisher's exact test, or Kruskal–Wallis equality-of-populations rank test, as appropriate.

In order to better estimate the association between these factors and unplanned readmission, we constructed a generalized estimated equation (GEE) to a fit multivariable, longitudinal regression model, clustered by patient. For the GEE model, a binomial family distribution was used; standard errors were adjusted for clustering. Our outcome was non-elective readmission within 12 months from index discharge. This outcome was recorded longitudinally as a dichotomous outcome (i.e., readmitted or not) for each of the months that followed the patients' index discharge. We limited our review to the first year after index discharge because subsequent readmissions would be expected in many of our patients as a natural sequelae of their progressive or severe medical conditions. Independent (i.e., predictor) variables for the regression model were selected from the characteristics above if their level of statistical significance in univariate analysis was $P < 0.2$. However, index LOS and change in management prior to index discharge were not included in the 12-month model, as their clinical relevance to readmission likely waned over time. Use of home care services and Pulmonology clinic visits were not considered for the model because they only pertain to patients who resided in a private home. Significant adjusted odds ratios (AOR) for nonelective readmission for predictor variable are presented with their 95% confidence intervals (CI) and P-values.

Summary data are presented as medians with interquartile ranges (IQR), means with standard deviations (SD), or as proportions. Statistical significance was determined using a P-value of 0.05 and by constructing 95% CI. Statistical analyses were performed using Stata 11 (StataCorp LP, College Station, TX). This review was approved by the CHLA Institutional Review Board.

RESULTS

One hundred and nine children and young adults were initiated on chronic mechanical ventilation via tracheostomy and followed at CHLA between January 2003 and October 2009. Three patients initiated on HMV at another hospital and referred to CHLA for further management were excluded. No patients over 21 years of age were initiated during the study period. No patients died within 1 year of index discharge.

The demographic and clinical characteristics of our cohort by non-elective readmission status are presented in Table 1. In univariate analysis, only having a change in medical management within 1 week prior to discharge was significantly associated with non-elective readmission. Of the ten patients that had changes made, eight (80%) were readmitted, and all of these readmissions occurred within 1 month post-index discharge. Three (30%) children had changes in ventilator settings; three (30%) had chronic medication changes/additions;

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two (20%) had antibiotics started for non-respiratory infections; and two (20%) had changes in their tracheostomy tube size.

The 1-month incidence of non-elective readmissions was 17% (19 patients); 22 (28%) of 78 total nonelective readmissions occurred within 1 month of index discharge. The 3-month incidence of non-elective readmission was 20% (22 patients); 36 (46%) non-elective readmissions occurred within 3 months. The 12-month incidence was 40% (44 patients). Twenty-six (33%) of the readmissions occurred January through March; 22 (28%) in April through June; 16 (21%) in July through September; and 14 (18%) in October through December. The reasons for these 78 unplanned readmissions are presented in Table 2. Sixty-four percent of our nonelective readmissions were pulmonary- or tracheostomy-related. Five patients with unplanned readmissions plus three others with no unplanned readmissions had 14 elective readmissions within 1 year of discharge. The mean number of non-elective readmissions per patient was 0.7 (SD ± 1.1; range 0–5). For the 44 patients with non-elective readmissions, the mean number of readmissions per patient was 1.9 (SD ± 1). The total days of hospitalization for these non-elective readmissions was 955—813 days on the ventilator ward and 142 days in the intensive care unit. For the entire cohort, the median number of days of rehospitalization was 0 (IQR 0–10). For the 44 patients who had a nonelective readmission, the median days of rehospitalization was 11 (IQR 8–25).

Using a GEE regression model for longitudinal data, which included age, neurodevelomental delay, epilepsy, feeding tube dependence, ventilator type, and place of residence as predictor variables, no statistically significant associations with non-elective readmission were found. Being on a non-continuous flow ventilator trended toward a positive association with readmission (AOR 1.79, 95% CI 0.97–3.3, P = 0.06), controlling for the variables just mentioned.

DISCUSSION

Repeated hospitalizations have been shown to occur disproportionately among children with complex chronic conditions. In a multi-institutional study, Berry et al.[2] reported that 22% of patients admitted to children's hospitals in 2003 had one or more readmissions within 1 year of a prior admission. Children with complex chronic conditions accounted for the majority of patients who had multiple readmissions. Unplanned readmissions are significant to patients and families as they indicate burden of illness. Potential consequences of recurrent acute illness include morbidity and mortality, as well as psychological, familial, and financial stressors. They are also significant for the healthcare system. Readmissions are costly, especially when they are to acute care settings, such as intensive care units.[2,11] In addition, avoidable readmissions may reflect of the quality of care the child received during the previous admission and at home and/or of the effectiveness the home ventilation program.[3,7] Some have suggested that readmissions should be used as a hospital performance indicator.[12] Examining the factors that are associated with readmissions is an important step in reducing them. Previous studies examined factors associated with readmission using univariate analysis and heterogeneous patient populations. Our analysis is the first to use multivariable regression models to examine possible risk factors for readmission in newly initiated ventilator-dependent children. Our study of 109 newly initiated pediatric HMV patients demonstrated that non-elective readmission was common, and many occurred shortly after index discharge. Moreover, those patients that had readmissions tended to have multiple ones. Similar findings were found by earlier studies with smaller cohorts, although direct comparisons are limited by the existing publications having used different or heterogeneous patient populations and outcomes. In a multi-institutional study, Berry et al.[13] showed that 846 children who had tracheotomies in 2002, of which 17% required chronic mechanical ventilatory support, had an average of 3.8 (SD ±

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4.4) hospitalizations during the subsequent 5 years. In a single-institutional study of 70 children with new tracheostomies, 66% of whom required prolonged mechanical ventilatory support, Graf et al.8 reported that 50% were readmitted within 3 months and 63% within 6 months. In Nelson et al.'s study of 89 children with various forms of HMV and lengths of follow-up between 1978 and 1993, 47% were readmitted to the hospital, and those readmitted averaged 1.7 readmissions per year.[7] Respiratory infection and elective surgery have been reported as common reasons for readmission for children on HMV.[4,7,13,14]

Using univariate and regression analysis, we found no statistically significant associations between nonelective readmissions and patient demographic or clinical characteristics. The one exception was having had a change in care management shortly before discharge was associated with being readmitted shortly afterwards. Eight (42%) of the 19 patients who had an unplanned readmission within 1 month of index discharge had a pre-discharge management change ($chi2 = 29.4$, $P < 0.001$). This association may suggest that when such a change occurs, caregivers should question whether this change reflects patient complexity, unsatisfactory discharge readiness, or some other reason. Our inability to identify other statistically significant risk factors may have been due to our relatively small cohort size, patient heterogeneity, interactions between factors, and/or unexplored factors.

As opposed Cushman et al.[4] who found an univariate association between hours per day of ventilator support and readmission, we found no such association. Cushman surmised that the greater number of ventilator hours per day was related to greater severity of lung disease. While this relation is likely true, we surmise that the underlying causes or associated factors of nonelective readmissions are difficult to isolate. Undoubtedly, they are multifactorial, involving interactions between the individual patient's clinical condition, social environment, quality of daily care, quality of medical management, etc.

Some of these factors are modifiable; thus, some of our cohorts' acute conditions and hospitalizations were potentially preventable. While we anticipated readmissions given our patients' complex conditions and significant comorbidities, we were struck that 33% and 31% of the non-elective readmissions amongst our cohort were upper and lower-airway related, respectively. These high proportions raised questions of whether some cases of pneumonia, tracheitis, tracheal decannulation, obstruction, and bleeding in our cohort were avoidable with, for example, better tracheostomy care. Caregiver training in tracheostomy and respiratory care is a focus of HMV discharge planning,[15] and we strive for better than sufficient training and postdischarge monitoring.[16] But these findings have prompted us to explore ways to supplement this training post-discharge. One of the authors (SSK) has initiated a project to profile the HMV knowledge and skills of home care providers (professional and familial) in order to identify their on-going educational needs and build a curriculum to address those needs.

Our study has several features which limit its inferences. First, it is a single-institutional study, although we suspect that other large ventilator programs have similar patient populations as ours. Second, we were only able to document readmissions to our own institution. While our cohort could have had non-elective readmissions to other hospitals, we postulate this number would have been quite small. Ours is the largest HMV program in the greater Los Angeles area; our anecdotal experience is that families and institutions prefer these children to be admitted or transferred to CHLA as soon as possible. Third, we did not explicitly attempt to explore preventable versus unpreventable readmissions. This would have been quite difficult to accurately discern with a retrospective study; although we have highlighted the likelihood that some of our readmissions were preventable. Fourth, we did not or could not include several potential confounders in our analysis, such as severity of comorbid conditions, psychosocial environment, socioeconomic status beyond insurance

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type, and out-patient changes and management. While such additional information would be beneficial in estimating more accurate measures of association, we were limited by our retrospective chart review and by our number of readmissions, which restricted the number of predictor variables we could include in the regression models. Similarly, there may have been confounding in the association between change in management prior to index discharge and subsequent non-elective admission. In other words, the patients who required a change in care plan may have been inherently different from other patients in such ways that they were more likely to be rehospitalized. Such bias can be reduced with larger cohort sizes and exploration of more confounders.

CONCLUSION

Awareness of ventilator-dependent children's risk for recurrent acute illness and hospitalization is important for setting realistic expectations for children, families, providers, and payers.4 As part of the anticipatory guidance provided in our HMV discharge preparation, we explain to families that, despite meticulous care, acute respiratory illnesses, or exacerbations of other comorbid conditions are possible, that home ventilators and other out-patient therapies can be inadequate during acute illness, and that rehospitalization is often necessary.

That being the case, programs such as ours are still charged with decreasing the frequency of acute illnesses and recurrent hospitalizations, in order to reduce their impact on patients, families, and the healthcare system. Further exploration of risk factors, especially those that can be manipulated, is necessary. For our HMV program, this study has led to two initiatives —first, a concerted reexamination of discharge readiness when a change is made in a child's clinical management as the expected discharge date approaches; and second, a project to survey and augment the HMV competencies of home caregivers.

Acknowledgments

The study was performed at Children's Hospital Los Angeles, Keck School of Medicine of the University of Southern California. Dr. Edwards is supported by a NICHD Pediatric Critical Care Scientist Development Program grant (K12 HD 047349).

ABBREVIATIONS

AOR	adjusted odds ratio
CHLA	Children's Hospital Los Angeles
CHS	central hypoventilation syndrome
CI	confidence interval
CPD	chronic pulmonary disease
CRF	chronic respiratory failure
GEE	generalized estimating equation
HMV	home mechanical ventilation
IQR	interquartile range
LOS	length of stay
PEEP	positive end expiratory pressure
SD	standard deviation

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VMW ventilatory muscle weakness

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TABLE 1

Characteristics of 109 Pediatric HMV Patients by Non-Elective Readmission Status

Characteristic, n (%)	Readmitted n = 44 (40)	Not readmitted n = 65 (60)	*P*-value
Male	27 (61)	39 (60)	0.89
Age at initiation, years, median (IQR)	0.83 (0.58–2.1)	1.1 (0.66–9.7)	0.1
Race/ethnicity			
Caucasian	8 (18)	5 (8)	0.13
Hispanic	26 (59)	46 (71)	0.21
African-American	7 (16)	11 (17)	0.89
Asian/Pacific-Islander/Middle-Eastern	3 (7)	3 (5)	0.68
Reason for CRF			
CPD	26 (59)	40 (62)	0.8
VMW	10 (23)	13 (20)	0.73
CHS	8 (18)	12 (18)	0.97
Comorbidities			
Cerebral palsy	7 (16)	11 (17)	0.89
Chromosomal anomaly/genetic abnormality	14 (32)	20 (31)	0.91
Congenital heart disease	22 (50)	25 (38)	0.23
Epilepsy	4 (9)	12 (18)	0.14
Feeding tube dependence	40 (91)	40 (77)	0.06
Neurodevelopmental delay	41 (93)	53 (82)	0.07
Prematurity, history of	20 (45)	31 (48)	0.82
Ventricular shunt dependence	4 (6)	5 (11)	0.48
LOS of index admission, days, median (IQR)	99 (66–160)	93 (54–128)	0.26
Change in management prior to discharge	8 (18)	2 (3)	0.014
Ventilator type			0.09
Continuous flow with PEEP	34 (77)	58 (89)	
Non-continuous flow without PEEP	10 (23)	7 (11)	
Hours of ventilatory support			0.31
≥16 hr/day	42 (95)	58 (89)	
<16 hr/day	2 (5)	7 (11)	
Initial disposition			0.2
Private home	37 (84)	48 (74)	
Sub-acute facility	7 (16)	17 (26)	
Insurance type			0.64
Private	14 (32)	25 (38)	
Public	30 (68)	40 (62)	
Professional home care services[1]	28 (76)	39 (81)	0.53
Pulmonology clinic visits within one year of index discharge, median number per patient (IQR)[1]	5 (4–6)	4 (4–6)	0.17

IQR interquartile range: LOS, length of stay: PEEP, positive end expiratory pressure.

[1]Pertains only to the 85 patients who resided in a private home.

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TABLE 2

Reasons for Non-Elective Readmissions

Reason	n (%)
Pneumonia	22 (28)
Tracheitis	13 (17)
Tracheostomy decannulation/obstruction	9 (11.5)
Abdominal pain/emesis	8 (10)
Infectious, other	5 (6.5)
Gastrointestinal, other	4 (5)
Tracheostomy bleeding	4 (5)
Failure to thrive/feeding intolerance	3 (4)
Neurosurgical	3 (4)
Dehydration/electrolyte imbalance	2 (2.5)
Respiratory, other	2 (2.5)
Seizures	2 (2.5)
Ophthalmologic	1 (1.5)
Total	78