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High Frequency Chest Wall Compression Therapy in Neurologically Impaired Children

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Conflict of interest statements:

Kathryn Fitzgerald served as a speaker at a single conference for HillRom, Inc in 2011.

Jessica Dugre has no conflict of interest related to the study

Sobhan Pagala has no conflict of interest related to the study

Peter Homer has no conflict of interest related to the study

Michael Marcus has no conflict of interest related to the study

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Abstract:

Background: Children with neurological impairment often suffer from insufficient airway secretion clearance, which substantially increases their respiratory morbidity. The goal of the study was to assess the clinical feasibility of high frequency chest wall compression (HFCWC) therapy in neurologically impaired children with respiratory symptoms.

Methods: This was a single-center, investigator initiated, prospective study. Twenty two patients were studied for 12 months before and 12 months after initiation of HFCWC therapy, 15 patients were followed up for additional 12 months. The threshold of compliance with HFCWC therapy was 70%. The amounts of pulmonary exacerbations, which required hospitalization, were recorded.

Results: Forty five percent of study patients required hospital admission before initiation of HFCWC therapy. This rate decreased to 36% after the first year of treatment and to 13% after the second year of treatment. There was a statistically significant reduction of the number of hospital days at follow-up relative to before treatment. Use of either the cough assist device or tracheostomy did not significantly interact over time with hospitalization days.

Conclusions: Prolonged HFCWC therapy may reduce the number of hospitalizations in neurologically impaired children.

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Introduction

Respiratory management of children with neurological impairment is complex.[1,2] Upper airway obstruction syndromes, reflux of gastric contents and aspiration, impaired lower respiratory secretion clearance due to weak cough, frequent lower respiratory tract infections (LRTI), chest wall deformities and related deformities of the tracheo-bronchial tree are all contributing factors to morbidity as well as posing a constant challenge to medical care providers.[3-6] Frequent LRTI require multiple courses of antibiotics and admissions to inpatient and pediatric intensive care units heavily burdening healthcare system.[7-9]

Impaired clearance of lower respiratory secretions leads to the development of acute and chronic LRTI, exacerbating a "build up" of lower respiratory secretions.[10,11] In an attempt to promote clearance of these lower respiratory secretions, chest physical therapy (chest PT) is often incorporated in the management of children with neurological impairment.[12,1,4] An appreciation of the role of impaired cough clearance in the respiratory morbidity of children with neuromuscular weakness lead to widespread use of the cough assistance device (mechanical insufflator-exsufflator), which was shown to be effective and now is strongly recommended as a standard of care in these children.[13-18] However, use of cough assistance device in children with cerebral palsy and other neurological syndromes has not yet been studied. Use of cough assistance device in these patients remains controversial and its implementation varies depending on the standards of a given institution.

Intrapulmonary percussive ventilation therapy was shown to be effective in adolescents and young adults with neuromuscular disease.[19]

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Other chest PT modalities include the use of end-expiratory positive pressure devices, manual chest PT as well as high frequency chest wall (HFCWC) therapy. The selection of chest PT methods used in this group of patients depend on several factors including the cognitive status of the patient, severity of respiratory compromise, and in many ways on the clinical experience of the clinicians.

There are limited data on the efficacy of HFCWC therapy in children with neurological impairment and no data on the impact of HFCWC on health care costs in this category of patients. We conducted a prospective study to evaluate the clinical feasibility of HFCWC therapy as a chest PT method in children with neurological impairment and respiratory symptoms. We hypothesized that use of HFCWC therapy decreases respiratory morbidity in this population of children. The objective of the study was to compare number of hospitalizations and hospital days in a group of children with neurological impairment and respiratory symptoms before and after the introduction of HFCWC therapy.

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Materials and Methods:

This was a single-center, investigator initiated, prospective study assessing the efficacy of HFCWC therapy in patients with severe neurological impairment and frequent pulmonary exacerbations.

The Institutional Review Board approved this study. The parents of all study patients gave informed consent to participate.

Patient Enrollment

Inclusion criteria were age greater than 18 months, a chest circumference greater than 19 inches, a diagnosis of neurological impairment and respiratory disorder defined as a history of two or more LRTIs associated with increased oxygen requirements which had led to hospitalization in the 12 months prior to study enrollment. Exclusion criteria included diagnosed allergy with a respiratory trigger, unstable head or spinal injury, unresolved pneumothorax or pneumomediastinum, unresolved hemorrhage, hypotension requiring vasopressors or positioning, bronchopleural fistula, gross hemoptysis, pulmonary embolism, burns, open wounds or skin infections on the thorax, osteomyelitis of the ribs, and osteoporosis with a history of fractures.

Follow-Up Patient Enrollment

Chart review was conducted 12 months after the cessation of the main study. Study patients whom completed the main study and remained compliant with HFCWC therapy were considered for enrollment in the follow-up study. Subjects were re-consented for the follow-up study and data collection was preformed retrospectively.

Study Procedures

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A complete physical assessment was performed at study enrollment, every three months during the study and at the final visit. Data points (Table 1) were collected during study visits and telephone interviews, which were conducted every 14 days for one year and after enrollment. Patients were allowed to continue their routine care, which may have included use of the cough assist device (CoughAssist® Mechanical In-Exsufflator, Respironics Inc., Murrisville, PA) and suctioning, as well as administration of anti-reflux, anti-seizure and other therapeutic agents "as usual".

HFCWC therapy was initialized upon study enrollment in eligible subjects. Once enrolled, a home visit was made for device fitting and training of subjects and caregivers on the HFCWC device. HFCWC therapy was provided using The Vest® Airway Clearance System, Model 105 (Hill-Rom Inc., St Paul, MN, US FDA #K993629). The Vest® System device has a built in hour meter to measure adherence. HFCWC therapy was used for the duration of 12 months, 20 minutes twice daily routinely, and increased up to four times a day for LRTIs associated with increased oxygen requirements. The settings were as follows: children from 18-36 months of age used a frequency of 10Hz and children above 36 months of age used a frequency of 12Hz. All patients used inflation pressures of 3 arbitrary units. The threshold for compliance with HFCWC therapy was 70%. Subjects whom were non-adherent with interventional therapy were not permitted to continue in the study and their HFCWC devices were picked up and returned to the company immediately after non-adherence was identified.

A six month "wash-in" period was established starting at the date of HFCWC initiation. The duration of the wash-in period reflected the suggestion that clinical benefits from HFCWC become more apparent after 6 months of treatment.[19] The data from the wash-

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in period were excluded from analysis. An equivalent six month period before treatment was also excluded from data analysis so that no seasonal difference skewed the data. A total of 12 months of data were analyzed for each respective subject (six months before initiation of therapy and six months after). For example, for a subject enrolled on 6/1/2009, data from 1/1/2009-6/31/2009 and 1/1/2010-6/31/2010 would be analyzed and compared. Equivalent six month periods before and after interventions were used so that no seasonal differences skewed the data. The study timeline is summarized in Figure I.

Follow-up Study Procedures

The study subjects were followed for twelve months after completion of the main study. The data from the last six months of HFCWC therapy were compared with those collected during the corresponding six months before therapy initiation. An equivalent six month period of data from the one year follow-up was compared with the previously collected data from the corresponding six month before study enrollment (Figure I).

Statistical Analysis

Data were summarized descriptively in terms of either mean ± standard deviation in the case of normally distributed variables, median (interquartile range) in the case of skewed continuous variables, and frequency (percent) in the case of categorical variables (e.g., sex). More than 50 % of the subjects had no hospital days (recorded as "0"), and so this outcome was dichotomized and summarized in terms of percent hospitalization ("yes/no"). A one sample chi-square test was used to test for differences in the proportion of subjects with different gender, race, diagnoses, technology modalities, and co-morbid conditions between the sample of subjects included in the Main Study and the subset of subjects who were included in the follow-up study. Difference between the

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subjects in the main study and those in the follow-up study in age was assessed with one sample t-test.

Primary outcome data were analyzed using general linear modeling (GLIM). GLIM allows for repeated measures analysis of subjects with missing data, under the assumption that the data are missing at random, so that all subjects were included for analysis. An underlying gamma distribution for skewed outcomes was assumed in order to compare the number of hospital days across time (i.e. "before" treatment versus "after" treatment and follow-up). The possible impact of cough-assist device (CAD) and tracheostomy upon outcome measures was analyzed by including appropriate group x time interactions in the GLIM analysis. Data were analyzed using SAS 9.1 (SAS, Inc., Cary, NC) for the GLIM. All analyses assumed a level of significance less than 0.05. Based on Giarraffa et al.[20] and Plioplys et al.[21,] the effect size for reduction in the number of hospital days was initially estimated to be between 1.36 and 1.55 days. Since these estimates appeared to be rather high, the lower one was reduced by half to 0.68. Based on this effect size, a minimum of 19 subjects was assumed to be needed to detect a paired difference of this magnitude, with an alpha of 0.05 and power of 80 %. Assuming a 25 % drop out rate, the minimum sample size for recruitment was determined to be 25.

Results:

Twenty nine subjects were consented for the main study. Four subjects were withdrawn due to non-adherence with HFCWC treatments, one patient refused treatment, one patient moved out of state, and one patient was institutionalized. Twenty-two subjects completed the main study. The mean age (years ± SD) of the main study subjects was 9.55 ± 5.57. 64% of study subjects had cerebral palsy and 45% had various other

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diagnoses. Forty five percent of study subjects were on positive pressure ventilation and 27% had tracheostomy (Table 2).

Of the 22 subjects who completed the main study; fifteen subjects were analyzed in the follow-up group. Five subjects were lost to follow-up, one subject was institutionalized, and one subject was excluded due to non-adherence during the follow-up period. The mean baseline age (years ± SD) of the follow-up group subjects was 9.44 ± 5.49 years. Comparison of main study group and follow up group did not show any differences in demographics, diagnosis or technology modalities (Table 2).

There was a statistically significant reduction in the number of hospital days at follow-up relative to before treatment ($p = 0.03$). Upon closer examination, this was due to a dramatic decrease in the rate of hospitalization at follow-up after HFCWC therapy (see Table 3). Forty five percent of study patients required hospital admission before initiation of HFCWO therapy. The rate of hospitalization then decreased to 36% after the first year of treatment ($p = 0.47$) and to 13% at follow up ($p = 0.002$). Use of either the cough assist device or tracheostomy did not significantly interact over time with hospitalization days (cough assist device, $p = .50$; tracheostomy, $p = 0.17$)

Discussion:

There are limited data on the role of HFCWC devices in the respiratory care of children with neurological impairment in peer-reviewed literature. One study showed that 12 months of HFCWC therapy resulted in a significant decrease of the number of pneumonias in children with CP, however, the sample size was very small, seven patients.[21] Yuan et al. [22], showed a trend towards the reduction of hospitalizations and

intravenous antibiotic use associated with HFCWC therapy in their randomized controlled trial of 23 patients with CP and neuromuscular disorders.

Our data demonstrate that HFCWC therapy resulted in a reduction of number of hospitalizations and hospital days during second year of intervention. It may suggest that prolonged use of HFCWC therapy brings additional benefits to children with neurological impairment and respiratory disorders. These findings concur with Warwick et al.[23], who showed long-term (7 to 26 months) use of HFCWC therapy provided significant change towards positivity in the negative slopes of lung function parameters in children with CF.

Patients with neurological impairment have multiple factors which predispose them to the retention of respiratory secretions and bronchiectasis formation,[24-26] which leads to development of the characteristic, abnormally thick and tenacious respiratory secretions. Plioplys et al.[21] studied applications of HFCWC therapy in children with neurological impairment and CP. They showed that HFCWC therapy dramatically increased "effective suctioning", defined as suctioning attempts which result in the aspiration of sputum (summation scores of effective suctioning 4,825 before treatment and 10,445 after treatment, $p = 0.008$). It is possible that HFCWC has a therapeutic effect in children with CP and neurological impairment via promoting the mobilization of tracheobronchial secretions and facilitating mucociliary clearance similarly to what has been previously shown in children with cystic fibrosis.[27]

As mentioned previously, impaired cough-related respiratory secretion clearance is a major contributor to respiratory morbidity.[2,12] Use of cough assistance was shown to be beneficial and is now recommended in children with congenital muscle dystrophies.[14] In

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our study the use of cough assist device did not significantly interact over time with reduction of hospitalization days in our group of patients that used HFCWC therapy. This raises the question of whether improving the rheological characteristics of airway secretions provides clinical benefit even in the absence of effective cough. It is possible that HFCWC therapy loosens the lower respiratory secretions sufficiently for effective mucociliary clearance to occur in this group of patients. However, this message has to be taken with caution. Acute respiratory deterioration after use of HFCWC was previously described in a child with cerebral palsy and was attributed to airway secretions mobilization in the presence of ineffective cough.[28] The authors suggested that the determination of the adequacy of cough effort should be performed before initiation of secretion mobilization treatments in this group of children. Since we did not perform the objective assessment of the cough efficacy in our patient population, we cannot come up with precise recommendation on utilization of cough-assist device in children with neurological impairment based on the results of this study.

Our study had certain limitations. Obviously, our study design is suboptimal because of the absence of a control group and randomization. Presence of control group would be desirable, because of well-accepted notion that HFCWC was not shown to be clinically superior to manual chest PT in children with CF.[29] However, introduction of a "control" group with manual chest PT into this study population may be challenging. Yuan et al.[22] studied the efficacy of HFCWC therapy in a group of children similar those in this study. The authors randomized children into two groups and reported that 7 of 12 children in the "manual" chest PT group were less than 30% adherent to the treatment regimen in contrast to the quite excellent adherence of the HFCWC group. Our own clinical

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experience concurs with these data. The presence of severe chest wall deformities in many patients with CP and neuromuscular impairment makes the delivery of effective manual chest PT close to impossible. The use of form-fitting wraps in deliverance of HFCWC therapy overcomes this problem and provides necessary treatments despite severe chest wall curvatures.

Our group of patients was very heterogeneous, mostly consisting of patients with CP but children with neurological impairment related to other conditions were also involved. These children suffered from different severities of respiratory compromise, including some receiving positive pressure ventilation. Obviously, we were unable to factor in all those differences.

We were able to show that the use of cough assist device and the presence of tracheostomy did not affect the hospitalization days but the inclusion of these confounders was post hoc and was not powered for the study outcome measures. Also, we did not monitor our patients' adherence to prescribed cough assist device.

In conclusion, the prolonged HFCWC therapy may reduce the number of hospitalizations and hospitalization days in children with neurological impairment. HFCWC should be considered as an important part of the complex approach to respiratory health in children with neurological impairment and suffering from chronic respiratory disorders. Future research efforts should be devoted to further defining the indications for initiation of this treatment modality in different groups of children with neurological impairment depending on their diagnosis, cognitive function, and the degree of their respiratory impairment.

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References

1. Birkrant DJ. The assessment and management of the respiratory complications of pediatric neuromuscular diseases. Clin Pediatr 2002;41(5):301-308.
2. Panitch HB. Respiratory issues in the management of children with neuromuscular disease. Respir Care 2006;51(8):885-895.
3. Seddon PC, Khan Y. Respiratory problems in children with neurological impairment. Arch Dis Child 2003;88(1):75-78.
4. Birnkrant D J. New challenges in the management of prolonged survivors of pediatric neuromuscular diseases: A pulmonologist's perspective. Pediatr Pulmonol 2006;41(12):1113-1117.
5. Burke RT, Alverson B. Impact of children with medically complex conditions. Pediatrics 2010;126(4):789-90.
6. Burns KH, Casey PH, Lyle RE, Mac Bird T, Fussell JJ, Robbins JM. Increasing prevalence of medically complex children in US hospitals. Pediatrics 2010;126(4):638-646.
7. Yates K, Festa M, Gillis J, Waters K, North K. Outcome of children with neuromuscular disease admitted to paediatric intensive care. Arch Disease Child 2004;89(2):170-175.
8. Simon TD, Berry J, Feudtner C, Stone B, Sheng X, Bratton SL, et al. Children with complex chronic conditions in inpatient hospital settings in the United States. Pediatrics 2010;126(4):647-655.

9. Truog RD, Brock DW, Cook DJ, Danis M, Luce JM, Rubenfeld GD, et al. Rationing in the intensive care unit. Crit Care Med 2006;34(4):958-963.

10. Panitch HB. Airway clearance in children with neuromuscular weakness. Curr Opin Pediatr 2006;18(3):277-287.

11. Tzeng AC, Bach JR. Prevention of pulmonary morbidity for patients with neuromuscular disease. Chest 2000;118(5):1390-1396.

12. Schramm, CM. Current concepts of respiratory complications of neuromuscular disease in children. Curr Opin Pediatr 2000;12(3):203-207.

13. Miske LJ, Hickey EM, Kolb SM, Weiner DJ, Panitch HB. Use of the mechanical in-exsufflator in pediatric patients with neuromuscular disease and impaired cough. Chest 2004;125(4);1406-1412.

14. Wang CH, Bonnemann CG, Rutkowski A, Sejersen T, Bellini J, Battista V, et al. Consensus statement on standard of care for congenital muscular dystrophies. J Child Neurol 2010;25(12):1559-1581.

15. Gauld LM. Airway clearance in neuromuscular weakness. Dev Med Child Neurol 2009;51(5):350-355.

16. Birnkrant DJ, Pope JF, Eiben RM. Management of the respiratory complications of neuromuscular diseases in the pediatric intensive care unit. J of Child Neurol 1999;14(3):139-144.

17. Bach JR. Mechanical insufflation/exsufflation: has it come of age? A commentary. Eur Respir J 2003;21(3):385-386.

18. Chatwin M, Ross E, Hart N, Nickol AH, Polkey MI, Simonds AK. Cough augmentation with mechanical insufflation/exsufflation in patients with neuromuscular weakness. Eur Respir J 2003;21(3):502-508.

19. Reardon CC, Christiansen D, Barnett E, Cabral HJ. Intrapulmonary percussive ventilation vs. incentive spirometry for children with neuromuscular disease. Arch Pediatr Adolesc Med 2005;159(6):526-531.

20. Giarraffa P, Berger KI, Chaikin AA, Axelrod FB, Davey C, Becker B. Assessing efficacy of high-frequency chest wall oscillation in patients with familial dysautonomia. Chest 2005; 128(5):3377-3381.

21. Plioplys AV, Lewis S, Kasnicka I. Pulmonary vest therapy in pediatric long-term care. J Am Med Dir Assoc 2002;3(5):318-321.

22. Yuan N, Kane P, Shelton K, Matel J, Becker BC, Moss RB. Safety, tolerability, and efficacy of high-frequency chest wall oscillation in pediatric patients with cerebral palsy and neuromuscular diseases: An exploratory randomized controlled trial. J Child Neurol 201:25(7):815-821.

23. Warwick WJ, Hansen LG. The long-term effect of high-frequency chest compression therapy on pulmonary complication of cystic fibrosis. Pediatr Pulmonol 1991;11(3):265-271.

24. King PT, Daviskas E. Pathogenesis and diagnosis of bronchiectasis. Breathe 2010;6:342-351.

25. Stafler P, Carr SB. Non-cystic fibrosis bronchiectasis: Its diagnosis and management. Arch Dis Child Educ Pract Ed 2010;95(3):73-82.

26. Piccione JC, McPhail GL, Fenchel MC, Brody AS, Boesch RP. Bronchiectasis in chronic pulmonary aspiration: Risk factors and clinical implications. Pediatr Pulmonol 2012;47(5):447-452.

27. Kluft J, Beker L, Castagnino M, Gaiser J, Chaney H, Fink RJ. A comparison of bronchial drainage treatments in cystic fibrosis. Pediatr Pulmonol 1996;22(4):271-274.

28. Willis LD, Warren RH. Acute hypoxemia in a child with neurological impairment associated with high frequency chest wall compression. Respir Care 2007;52(8):1027-1029.

29. Arens R, Gozal D, Omlin KJ, Vega J, Boyd KP, Keens T, et al. Comparison of high frequency chest compression and conventional chest physiotherapy in hospitalized patients with cystic fibrosis. Am J Respir Crit Care Med 1994;150(4):1154-1157.

Figure legends:

Figure 1. The study timeline

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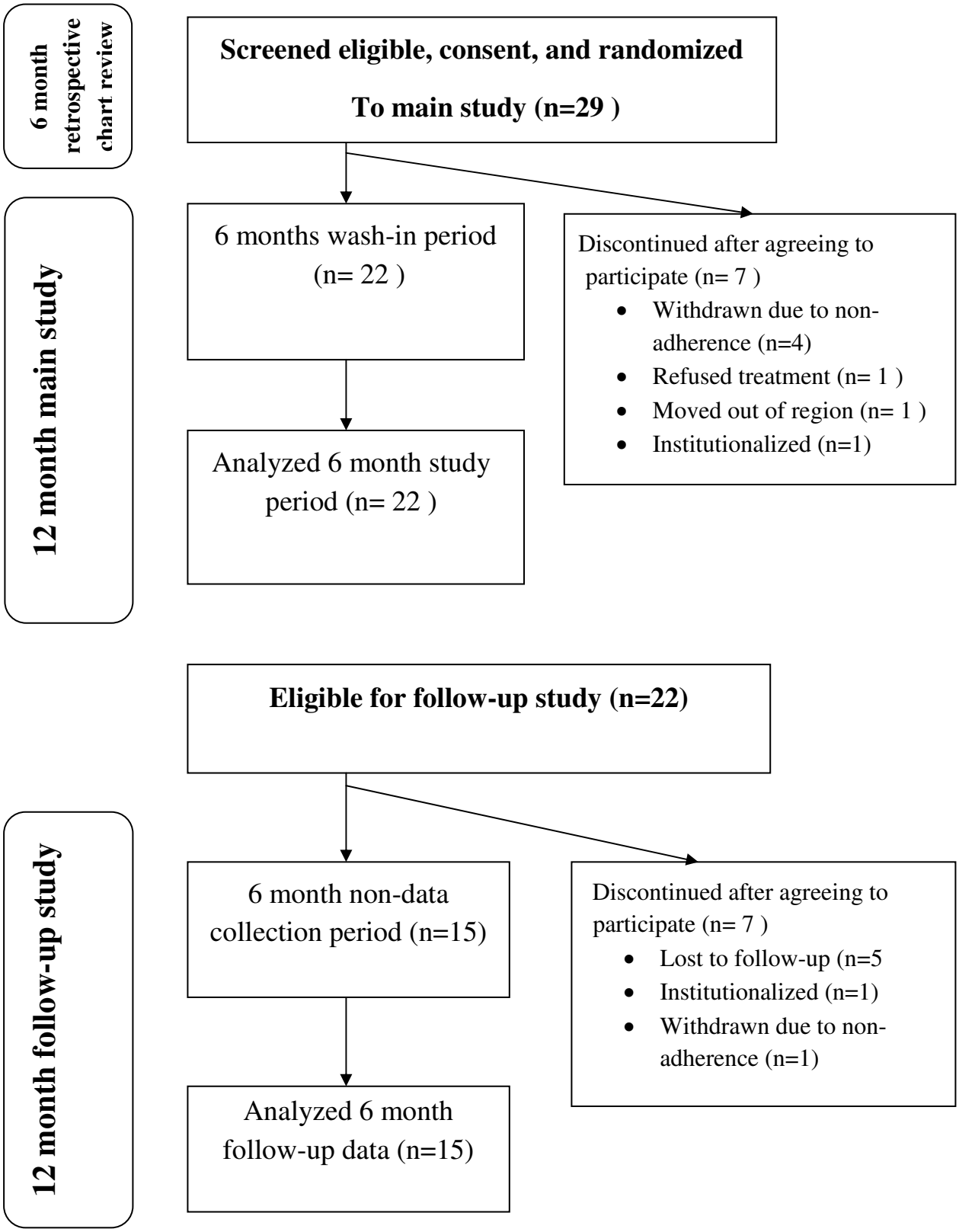

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Table 1. Data Assessment

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Assessment	Baseline	Monthly	As Occurs	Study Exit
Eligibility Data	X			
Demographic Data	X			
Medical History	X			
Vest Hour Meter Readings		X		X
Hospitalizations			X	X
Antibiotics			X	X
Clinic Visits			X	X
Adverse Events			X	X
Protocol Deviations			X	X

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Table 2. Demographics and clinical characteristics of subjects who received HFCWC therapy

	Main study (N=22)		Follow-up (N=15)		
Parameter	**N**	**%**	**N**	**%**	**P-value**
Age	22	9.55 ± 5.57	15	9.44 ± 5.49	0.95
Sex					
Male	14	64	8	53	0.58
Female	8	36	7	47	
Race					
African American	5	23	2	13	0.84
Asian	3	14	2	13	
Caucasian	8	36	6	40	
Hispanic	6	27	5	33	
Diagnosis					
Cerebral palsy	14	64	9	60	0.47
Brain Malformation	4	18	3	20	0.52
Static Encephalopathy	1	5	1	7	0.54
Myopathy	1	5	0	0	0.46
Neurodegenerative Disease	2	9	2	13	0.40

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Technology modalities					
Bipap	6	27	3	20	0.73
Cough Assist	12	55	9	60	0.86
Ventilator	4	18	2	13	0.60
Oxygen	9	41	7	47	0.84
G-tube	18	82	12	80	1.00
Tracheostomy	6	27	3	20	0.73
Co-morbidities					
GERD	16	73	11	73	1.00
Seizure disorder	14	64	10	67	1.00
Scoliosis	16	73	9	60	0.42

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Table 3. Rate of Hospital admissions comparing patients before and after initiation of HFCWC treatment and at follow-up

Time	Hospitalized		p-value [a]
	No	Yes	
Before treatment (n = 22)	12 (55) % [b]	10 (45 %)	NA
After Treatment (n = 22)	14 (64 %)	8 (36 %)	0.47
Follow-up (n = 15)	13 (87 %)	2 (13 %)	0.002

[a] p-value for Rate of Hospitalization relative to Before HFCWC Treatment
[b] frequency (percent)