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The effects of assisted autogenic drainage, combined or not with bouncing on gastroesophageal reflux in infants

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ABSTRACT

AIM: This study aimed to determine the effect of assisted autogenic drainage (AAD) with or without bouncing (BAAD) on both acid and non-acid gastroesophageal reflux (GER) in infants <1 year.

Methods: During a 24-h multichannel intraluminal impedance-pH monitoring (MII-pH), infants were treated with a 20-min intervention of AAD (in supine position) or BAAD (in upright position), 2-h postprandial. In this controlled trial with intra-subject design, the number of reflux episodes (REs) was the primary outcome measure. The results during AAD and BAAD were compared to a baseline period before intervention and 20-min after intervention.

Results: Overall, 50 infants were included in both groups. During AAD a significant decrease of RE's was found compared to baseline ($p = 0.001$). No significant differences were found in the BAAD group compared to baseline ($p = 0.125$).

Conclusion: AAD and BAAD do not cause or increase GER in infants under the age of 1 year.

KEY NOTES

- Certain airway clearance techniques can exacerbate gastroesophageal reflux (GER). Refluxed gastric contents may potentially impair pulmonary function through reflex bronchospasm and micro-aspiration. The effects of assisted autogenic drainage (AAD) with or without bouncing (BAAD) on both acid and non-acid GER were not well documented.
- The results of the study established that both 20-min treatment sessions regardless of the indication or result of the 24-h MII-pH monitoring, do not cause an increase in both acid and non-acid reflux episodes in infants younger than 1 year.
- AAD and BAAD are safe for infants under the age of 1 year even the ones who are suspected of having GERD.

KEY WORDS: Airway clearance techniques, assisted autogenic drainage, bouncing, gastroesophageal reflux, MII-pH monitoring

INTRODUCTION

Assisted autogenic drainage (AAD) is an effective airway clearance technique (ACT) used in patients unable to carry out autogenic drainage independently to maintain respiratory function and prevent deterioration of bronchial obstruction or hypersecretion.(1) The technique, developed by Jean Chevaillier is characterized by controlled breathing using expiratory airflow to mobilise secretions from distal to proximal airways, without causing dynamic airway collapse.(1) AAD can be performed in different positions to alter regional ventilation and improve mucus clearance.(2,3) Its effectiveness has been showed in the treatment of hospitalised infants with bronchiolitis(4), uncomplicated pneumonia(5), and cystic fibrosis(6). In infants with acute bronchiolitis, AAD reduces significantly the length of hospital stay and respiratory symptoms of bronchial obstruction.(4) In infants with uncomplicated pneumonia, AAD might be considered safe and effective.(5) In infants with cystic fibrosis, AAD is effective but not superior to any other form of ACT.(6) The AAD technique is commonly used. In a large study in 166 centers in 27 different countries, 1 of 3 centres used AAD to treat infants with Cystic Fibrosis.(7) Sometimes, AAD is combined with bouncing (BAAD). This is a rhythmic up-and-down movement on a physioball to relax the baby and to enhance the expiratory air velocity.

Gastroesophageal reflux (GER) can be exacerbated by certain ACT's.(8) GER is defined as 'the passage of gastric contents into the oesophagus or oropharynx, with or without regurgitation and/or vomiting'.(9) It is a normal physiologic process as almost 50% of all healthy infants regurgitate at least once a day, most often after a meal and is for the most part associated with transient relaxations of the lower esophageal sphincter.(10,11) The prevalence of regurgitation peaks at the age of 4 months and shows a steady decline in frequency with almost complete disappearance of symptoms at the age of 12 months in 90% of cases.(10,11) GER becomes a gastroesophageal reflux disease (GERD) when reflux increases in intensity or frequency and causes complications or troublesome symptoms like coughing, laryngitis, and wheezing.(9,10) In children of all ages, GERD is the most common esophageal disorder.(10) It is a risk factor for feeding disorders, a few neurological disorders, and respiratory disorders that include asthma, chronic cough, chronic hoarseness, other laryngeal disorders, and recurrent pneumonia through reflex bronchospasm and micro-aspiration.(12),(13)

The availability of oesophageal 24-h multichannel intraluminal impedance monitoring in combination with pH-metry (pH-MII) provided new insights into the diagnosis towards atypical manifestations of GERD.(14) It is based on changes in electrical resistance between 2 electrodes placed on the MII probe when a bolus moves between them.(13) The technique implemented both acid and non-acid reflux episodes (REs) as in healthy patients about 33-38% of REs are non-acid(15,16) and in patients with GERD 50% of REs are non-acid(17) and would remain undetected with standard pH probe analysis.(12) More advantages over standard pH assessment are the ability to recognize swallows (antegrade flow) from authentic reflux episodes (retrograde flow), detecting the height and composition of the refluxate, and measuring symptom association with reflux.(13)

Up to date, four studies investigated the influence of a modern ACT on GER. Lee et al. found that upright positive expiratory pressure therapy and exercise did not increase the frequency of GER in patients with COPD or bronchiectasis.(18) Our group(19) found that intrapulmonary percussive ventilation in upright position does not induce nor aggravate GER in infants. The influence of AAD, whether or not combined with bouncing, on acid GER was investigated by our group.(20). New insights highlight the importance of non-acid reflux in GERD. We aimed to determine the influence of AAD and AAD combined with bouncing on both acid and non-acid GER in infants under the age of 1 year. The number of reflux episodes (REs) was our primary outcome measure. The results during AAD and BAAD were compared to a baseline period before and after intervention in each infant.

METHODS

Patients

Each infant referred to the hospital to confirm a clinically suspected GERD diagnosis with 24-h MII-pH and younger than 1 year was included in this controlled trial. Their parents were informed about the study, and those who wanted to participate provided written informed consent. Exclusion criteria are gestational age less than 37 weeks, and any anti-reflux treatment (such as Nissen fundoplication or medication), since reflux treatment could bias our results. One hundred and five patients were included between 1 February 2019 and 10 December 2020. The study was approved by the UZ Brussel ethics committee (B.U.N. 143201835557) and registered at ClinicalTrials.gov (NCT03346174).

Materials

Each MII-pH over 24-h was performed using a Sandhill Scientific MII-pH monitoring system (Denver, CO, USA) and an appropriate infant MII-pH catheter with seven impedance sensors and one distal pH-sensor (calibrated in pH 4.0 and pH 7.0 buffers). The full MII-pH was analyzed by an experienced pediatric gastroenterologist (YV).

A retrograde drop in impedance by more than 50% of baseline in at least two distal impedance sensors was defined as a RE. The REs were considered to be acid if the pH was lower than 4.0 for more than 5 seconds and as non-acid if the pH was above 4.0 for more than 5 seconds. The MII-pH was abnormal if the percentage of time that the esophageal pH was lower than 4.0 was more than 7.0% or if the number of REs according to the MII analysis was more than 100 over a 24-h period.(9,21)

Intervention and baseline

Patients were exclusively assigned to the AAD or BAAD group based on the order of presentation: pair numbers of included patients to AAD and unpair numbers to BAAD group.

1) Assisted autogenic drainage (AAD)

AAD performed in supine position is an ACT used in patients unable to carry out treatment independently based upon the principles of autogenic drainage (AD). During AAD, the functional breathing level within the vital capacity is modulated with a gentle increase of manuel pressure on the chest. This optimizes the airflow in the targeted airways and improves ventilation and mucus clearance.

Feedback (hearing or feeling the secretions move) is essential. (4,7)

2) Bouncing in combination with AAD (BAAD)

Bouncing is a gentle up and down movement on a physioball in a well-supported 90° sitting position with an amplitude between 6 and 8 cm, to maximize the relaxation of the infant to avoid crying or resistance against AAD, making the treatment more effective.(4)

Infants were treated for 20-min by one of the two experienced and trained physiotherapists (FV,SV). To exclude any influence of feeding on GER, the interventions started 120-min after feeding. In a pilot study in 10 infants hospitalised with acute bronchiolitis, we found a mean reduction of 6% of the chest circumference while performing AAD as an ACT.(20) To standardise the treatment in both intervention groups, bouncing amplitude is limited to 6-8 cm, and the chest circumference during AAD is reduced by 6%, measured at rest at the height of the nipple line with a measuring tape (SECA, Hamburg, Germany).

In both groups, the number of acid and non-acid REs and the number of REs migrating proximally, before (control), during, and after treatment were calculated by a computer program without human interference. Pre-treatment, treatment and post-treatment were of the same length: 20-min. Blinded to group allocation, MII-pH recordings were read out by an experienced pediatric gastroenterologist (YV). Data were analysed for the entire group. Subgroup analysis was performed for the subgroups with and without normal MII-pH and depending on the reason for referral.

Statistical analysis

To provide normal values for infants <1 year, our group performed an interim analysis of 15 infants implementing MII-PH.(22) Over sixty-one 20-min periods (2-h after the last meal), REs were measured, resulting in a mean of 0.98 REs (SD = 0.66) for each infant.(22) Power calculation based on these results estimated that 50 subjects would be required to detect a 50% change in the number of REs during the treatment sessions with a power of 95% at the 5% significance level.(22) Shapiro-Wilk and Kolmogorov-Smirnov Goodness of Fit tests revealed that the data were not normally distributed. To compare differences in REs between baseline (pre-treatment), the treatment period, and 20-min after treatment (post-treatment), Friedman's Two-way Analysis of Variance Test was used with a statistical significance of $P < 0.05$. In case of significance, post hoc Wilcoxon signed-rank tests with Bonferroni correction were used to detect the differences. After Bonferroni correction, statistical significance was accepted for $p < 0.017$.

RESULTS

Baseline characteristics of the participants

A total of 105 infants <1 year were screened and evenly distributed over the two groups. Two infants in the AAD group and three infants in the BAAD removed the probe accidentally during the 24-h pH-MII (Figure 1). Infants were their own controls. Demographics of the included participants are presented in Table 1.

Upon the MII-pH results, 23 infants in the AAD group and 15 infants in the BAAD group were diagnosed with GER. Fifteen infants in the AAD group and 20 infants in the BAAD group were referred with troublesome regurgitation and vomiting, 14 infants in the AAD group and 14 infants in de BAAD group) with a chronic cough and/or wheezing, 20 infants in the AAD group and 13 infants in the BAAD group with inconsolable crying, and one infant in the AAD group and 3 infants in the BAAD group with suspicion of brief, resolved and unexplained events (Table 1).

MII-pH monitoring

Reflux Episodes before treatment (baseline), 2-h Post-prandial

Sixty-nine REs (30 acid and 39 non-acid REs) in the AAD group and 89 REs (26 acid and 63 non-acid REs) in the BAAD were measured during the MII-pH monitoring. Ninety-seven percent of all REs in the AAD group and 88% of all REs in the BAAD group migrated proximally (Table 2 and Table 3).

Reflux episodes during AAD en BAAD

During AAD, 41 REs were detected. Twenty-two REs were acid and 19 non-acid. Ninety-five percent of the total number of REs migrated proximally. During BAAD, 75 REs were measured. Twenty were acid and 55 REs non-acid. Eighty-nine percent migrated proximally (Table 2).

Reflux episodes after AAD and BAAD

In the 20-min following the treatment, 53 REs were detected in the ADD group and 63 REs in the BAAD group. In the AAD group, 19 REs were acid, 34 were non-acid and 96% migrated proximally. In the BAAD group, 17 REs were acid, 46 were non-acid and 92% migrated proximally (Table 3).

Comparison of reflux episodes between before, during, and after AAD and BAAD

Results in the AAD group

In the entire group, the total REs during AAD (n = 41) decreased significantly compared to baseline (n = 69) (p = .001). Also, non-acid REs (n = 19) and the proximally migrating REs (n = 39) decreased significantly compared to baseline (respectively n = 39, n = 67; p = .002, p = .001). Further post hoc analysis indicated that in the other groups classified by reason for referral, no significant differences were found in REs between the three measuring points after Bonferroni correction (Table 2).

Results in the BAAD group

In total, acid, non-acid or proximally migrating REs, no significant differences after Bonferroni correction were found between the three measuring points. The same was found after further post hoc analysis (Table 3).

DISCUSSION

The results of this study revealed that Assisted autogenic drainage whether or not combined with bouncing and regardless of the indication or result of the 24-h MII-pH monitoring, does not cause an increase in reflux episodes in infants under the age of 1 year. Even more, we showed that in the entire group the total number of REs, the non-acid number of REs, and the number of REs migrating proximally during AAD significantly decreased in comparison to the number of REs before treatment (baseline).

A limited number of studies already investigated the influence of modern ACT's on GER but there is still a lack of evidence.(8,19,20,23) The effect of gravity-assisted chest physiotherapy techniques on GER focussing on head-down tilt whether or not in combination with percussion, vibrations, chest clapping, and thoracic compression has already been investigated.(24–27) Evidence of these techniques is missing and the use of gravity-assisted positions is not recommended.(8) Trendelenburg or head-down position is known to aggravate GER and head-elevated position or anti-Trendelenburg to decrease GER in infants.(8) The effectiveness of AAD as an ACT in the treatment of infants with acute respiratory infections has already been studied.(4–6) Avoiding or reducing GER during AAD and BAAD is an important added value especially in the group with GERD. When respiratory physiotherapy induce GER it may exacerbate the severity of this condition.

Nowadays, only one group investigated the influence of AAD and BAAD on GER with oesophageal pH monitoring.(20) It is known that non-acid GER is more associated compared with acid reflux with persistent respiratory symptoms in infants.(28) Reflux, but mainly non-acid reflux, was shown to precede cough.(29) The use of oesophageal pH monitoring, detecting only acid REs is, therefore, a limitation to this study. Based on the results of the MII-pH monitoring, we now know that AAD and BAAD do not increase both acid as non-acid REs. We can conclude that AAD and BAAD are not contraindicated and thus safe for infants under the age of 1 year even the ones who are suspected with GERD.

We only found a significant decrease in the number of REs in the total group between pre and during AAD treatment and not in the BAAD group. These results are supported by the previous study of our group.(20) The largest difference between the two groups is the well-supported 90° sitting position during BAAD instead of a supine position during AAD. The most important underlying mechanism of GER is transient lower esophageal sphincter relaxation. Posture has an impact on the frequency of transient lower esophageal sphincter relaxation.(30) Due to weak trunk muscles infants usually adopt slumped postures in an upright position, increasing intra-abdominal pressure, and inducing GER.(31) A well-supported 90° sitting position prevents crying and slumped sitting and thus prevents GER.(32) In the AAD group, we found no significant differences in the subgroups, only in the subgroup with patients referred for crying. In the BAAD subgroups, there was just a significant decrease in the total number of REs in the group with abnormal MII-pH. No data have been published to support our findings. The lack of any other significant decrease is probably due to underpowering which is a limitation to this study.

It is known that effective airway clearance reduces airway obstruction; promotes lung expansion and function; and decreases the inspiratory effort.(4) As a result of these responses, it is possible that ACT's, such as AAD and BAAD, may decrease intrathoracic pressure and counteract the effect of elevated intrapleural pressure which reduces GER.(33) Another hypothesis is that during AAD and BAAD a steady pressure is given on the chest which can explain a decrease in reflux by an increased mean oesophageal pressure through a direct transmission of pressure (= mechanical barrier).(34)

CONCLUSION

Assisted autogenic drainage whether or not combined with bouncing and regardless of the indication or result of the 24-h MII-pH monitoring, does not cause an increase in both acid as non- acid reflux episodes in infants under the age of 1 year. AAD and BAAD are safe for infants under the age of 1 year even the ones who are suspected of having GERD.

SPECIFIC CONTRIBUTIONS

Laure Lievens: Literature search, analysis of data, manuscript preparation

Yvan Vandenplas: Study design, analyzes of measurements, review of the manuscript

Sylvie Vanlaethem: Study design, data collection

Filip Van Ginderdeuren: Data collection, study design, review of manuscript

COMPLETE LIST OF ABBREVIATIONS

Assisted autogenic drainage (AAD)

Assisted autogenic drainage combined with bouncing (BAAD)

Gastroesophageal reflux (GER)

Multichannel intraluminal impedance-pH monitoring (MII-pH)

Reflux episodes (REs)

Gastroesophageal reflux disease (GERD)

Airway clearance technique (ACT)

STATEMENTS

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TABLES

Table 1 - Patients demographics

	AAD	BAAD
Sex (male / female)	29/21	30/20
Median age in days (range)	126	127
Reflux diagnosis (yes/no)	23/27	15/35
Reason for referral		
Regurgitation/vomiting (%)	15 (30)	20 (40)
Cough/wheezing (%)	14 (28)	14 (30)
Crying (%)	20 (40)	13 (26)
Brief, resolved, unexplained events (%)	1 (2)	3 (4)

Table 2 - Results of the MII-pH monitoring: differences between pre-AAD, AAD and post-AAD

			Total	Pre-AAD	AAD	Post-AAD	P value
All patients	N° infants		50	50	50	50	
	N° infants with REs			34 (68%)	29 (58%)	27 (54%)	0.338*
	N° REs		163	69 (42%)	41 (25%)	53 (33%)	0.021**
		Medians (IQR 25%-75%)		1 (0-2)	1 (0-1)	1 (0-2)	0.021**
All patients with abnormal MII-pH	N° infants		23	23 (46%)	23 (46%)	23 (46%)	
	N° infants with REs			16 (70%)	13 (57%)	11 (48%)	0.323*
	N° REs		70	31 (44%)	19 (27%)	20 (29%)	0.125**
		Medians (IQR 25%-75%)		1 (0-2)	1 (0-2)	0 (0-1)	0.125**
All patients with normal MII-pH	N° infants		27	27 (54%)	27 (54%)	27 (54%)	
	N° infants with REs			18 (67%)	16 (59%)	16 (59%)	0.948*
	N° REs		93	38 (41%)	22 (24%)	33 (35%)	0.13**
		Medians (IQR 25%-75%)		1 (0-2)	1 (0-1)	1 (0-2)	0.13**

Legend: AAD: Assisted autogenic drainage; N°: number; REs: reflux episodes.

Statistics: *Crosstabs, Chi-square, P = 0.05. **Friedman test, P = 0.05.

Table 3 - Results of the MII-pH monitoring: differences between pre-BAAD, BAAD and post-BAAD

			Total	Pre-BAAD	BAAD	Post-BAAD	P value
All patients	N° infants		50	50	50	50	
	N° infants with REs			35 (70%)	38 (76%)	36 (72%)	0.791*
	N° REs		227	89 (39%)	75 (33%)	63 (28%)	0.125**
		Medians (IQR 25%-75%)		1,5 (0-3)	1 (0,75-2)	1 (0-2)	0.125**
All patients with abnormal MII-pH	N° infants		15	15 (30%)	15 (30%)	15 (30%)	
	N° infants with REs			12 (80%)	11 (73%)	13 (87%)	0.659*
	N° REs		85	38 (45%)	27 (32%)	20 (24%)	0.038**
		Medians (IQR 25%-75%)		3 (1-4)	2 (0-3)	1 (1-2)	0.038**
All patients with normal MII-pH	N° infants		35	35 (70%)	35 (70%)	35 (70%)	
	N° infants with REs			23 (66%)	27 (77%)	23 (66%)	0.487*
	N° REs		142	51 (36%)	48 (34%)	43 (30%)	0.731**
		Medians (IQR 25%-75%)		1 (0-2)	1 (1-2)	1 (0-2)	0.731**

Legend: BAAD: Assisted autogenic drainage combined with bouncing; N°: number; REs: reflux episodes.

Statistics: *Crosstabs, Chi-square, P = 0.05. **Friedman test, P = 0.05.

Online table 4 - Results of the pH-MII monitoring in the AAD group

		Total	Pre-AAD	AAD	Post-AAD	P value
All patients	N° infants	50	50	50	50	
	N° infants with REs		34 (68%)	29 (58%)	27 (54%)	0,338
	N° REs	163	69 (42%)	41 (25%)	53 (33%)	0,021*
	N° acid REs		30 (43%)	22 (54%)	19 (36%)	0,308
	N° non-acid REs		39 (57%)	19 (46%)	34 (64%)	0,009*
	N° REs migrating proximally		67 (97%)	39 (95%)	51 (96%)	0,021*
All patients with abnormal MII-pH	N° infants	23	23	23	23	
	N° infants with REs		16 (70%)	13 (57%)	11 (48%)	0,323
	N° REs	70	31 (44%)	19 (27%)	20 (29%)	0,125
	N° acid REs		17 (55%)	14 (74%)	8 (40%)	0,206
	N° non-acid REs		14 (45%)	5 (26%)	12 (60%)	0,115
	N° REs migrating proximally		29 (94%)	18 (95%)	19 (95%)	0,27
All patients with normal MII-pH	N° infants	27	27	27	27	
	N° infants with REs		18 (67%)	16 (59%)	16 (59%)	0,948
	N° REs	93	38 (41%)	22 (24%)	33 (35%)	0,13
	N° acid REs		13 (34%)	8 (36%)	11 (33%)	0,773
	N° non-acid REs		25 (66%)	14 (64%)	22 (67%)	0,076
	N° REs migrating proximally		38 (100%)	21 (95%)	32 (97%)	0,068
All patients referred for regurgitation / vomiting	N° infants	15	15	15	15	
	N° infants with REs		11 (73%)	9 (60%)	9 (60%)	0,678
	N° REs	45	17 (38%)	11 (24%)	17 (38%)	0,428

	N° acid REs		6 (35%)	6 (55%)	3 (18%)	0,527
	N° non-acid REs		11 (65%)	5 (45%)	14 (82%)	0,227
	N° REs migrating proximally		15 (88%)	10 (91%)	16 (94%)	0,509
All patients referred for cough/ wheezing	N° infants	14	14	14	14	
	N° infants with REs		8 (57%)	8 (57%)	5 (36%)	0,424
	N° REs	41	18 (44%)	9 (22%)	14 (34%)	0,488
	N° acid REs		8 (44%)	6 (67%)	4 (29%)	0,215
	N° non-acid REs		10 (56%)	3 (33%)	10 (71%)	0,167
	N° REs migrating proximally		18 (100%)	9 (100%)	14 (100%)	0,488
All patients referred for crying	N° infants	20	20	20	20	
	N° infants with REs		15 (75%)	12 (60%)	13 (65%)	0,592
	N° REs	77	34 (44%)	21 (27%)	22 (29%)	0,040*
	N° acid REs		16 (47%)	10 (48%)	12 (55%)	0,519
	N° non-acid REs		18 (53%)	11 (52%)	10 (45%)	0,044*
	N° REs migrating proximally		34 (100%)	20 (95%)	21 (95%)	0,023*
All patients referred for BRUE	N° infants	1	1	1	1	
	N° infants with REs		0	0	0	
	N° REs	0	0	0	0	
	N° acid REs		0	0	0	
	N° non-acid REs		0	0	0	
	N° REs migrating proximally		0	0	0	

Legend: AAD: Assisted autogenic drainage; N°: Number; REs: Reflux episodes.
Statistics: *crosstabs, chi-square, p = 0,05. **Friedman test, p = 0,05.

FIGURE LEGENDS

Figure 1 – Recruitment of study participants

FIGURES

Figure 1