

DOI: <https://doi.org/10.5554/22562087.e1168>

Effect of an education program for healthcare professionals focused on the detection and management of reverse triggering: Secondary analysis of a quasi-experimental study

Efecto de un programa de educación para profesionales sanitarios en la detección y manejo del gatillaje reverso: Análisis secundario de un estudio cuasiexperimental

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Abstract

What do we know about this problem?

Detection of reverse triggering (RT) based on the analysis of the different curves provided by mechanical ventilators poses a great challenge to healthcare staff working in intensive care units (ICU). The ability to identify RT, reported by some studies, is not greater than 59%, and only 50% of the healthcare professionals are able to correctly respond to this type of patient-ventilator asynchrony.

How does this study contribute?

In Chile, attending a specific education program focused on PVA recognition and resolution could result in an improved ability among critical care staff to identify and resolve RT based on ventilation graph analysis.

How to cite this article:

Ramírez Venegas I, Gutiérrez-Arias R. Effect of an education program for healthcare professionals focused on the detection and management of reverse triggering: Secondary analysis of a quasi-experimental study. Colombian Journal of Anesthesiology. 2026;54:e1168.

Introduction: Reverse triggering (RT) is a frequent type of patient-ventilator asynchrony (PVA). Despite the potential complications associated with this type of asynchrony, there is a scarcity of literature regarding the effects of training programs aimed at developing the necessary competencies among healthcare professionals to help them identify and resolve this type of PVA.

Objective: To assess the effect on Chilean intensive care professionals of an education program specifically focusing on RT detection and management using ventilation graph analysis, both immediately as well as after 30 days.

Methods: A secondary analysis based on the data used in a quasi-experimental study was conducted. The study applied an education program to improve detection and management of various types of PVA by healthcare staff working in critical care, using ventilation graph analysis. Assessments were conducted before (T₀), immediately after (T₁) a six-hour online session, and 30 days later (T₂). Information from the questions designed to identify the ability to recognize and resolve RT was extracted.

Results: In total, 49 healthcare professionals were included, 94% of them physical therapists, with a mean experience of three years (IQR 0.9 to 4). At T₀, 20% answered the three questions correctly, with a significant increase at T₁ (73.47%) and at T₂ (69.39%) ($p < 0.001$).

Conclusions: In Chile, attending a specific education program focused on PVA recognition and resolution could result in an improved ability among critical care staff to identify and resolve RT based on ventilation graph analysis.

Keywords: Patient-ventilator asynchrony; Respiration, artificial; Critical care; Respiratory therapy; Ventilators, mechanical; Health personnel; Health education.

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Resumen

Introducción: El gatillaje reverso (GR) es un tipo frecuente de asincronía paciente-ventilador (APV). A pesar de las potenciales complicaciones asociadas a este tipo de asincronía, en la actualidad existen escasos reportes sobre los efectos de programas de formación que permitan a los profesionales de la salud adquirir las competencias necesarias para identificar y resolver este tipo de APV.

Objetivo: Evaluar el efecto en profesionales chilenos de cuidados intensivos de un programa específico de educación en la detección y manejo inmediato y al mes de seguimiento del GR mediante el análisis de la gráfica ventilatoria.

Métodos: Se hizo un análisis secundario a partir de los datos utilizados en un estudio cuasiexperimental. En dicho estudio se aplicó un programa de educación para mejorar la detección y manejo de diferentes APV de profesionales de la salud de cuidados críticos mediante el análisis de la gráfica ventilatoria. Se aplicó una herramienta de evaluación antes (T_0) y después (T_1) de una sesión en línea de seis horas, y 30 días después (T_2). Se extrajo la información de las preguntas destinadas a conocer la habilidad para reconocer y resolver el GR.

Resultados: Se incluyeron 49 profesionales, 94 % fisioterapeutas, con una mediana de experiencia de tres años (RIC 0,9 a 4). Un 20 % respondió correctamente las tres preguntas en el momento T_0 , lo que aumentó de manera significativa en el T_1 (73,47 %) y el T_2 (69,39 %) ($p < 0,001$).

Conclusiones: Participar en un programa de educación específico sobre el reconocimiento y resolución de APV podría contribuir a que profesionales chilenos de cuidado crítico mejoren su habilidad para identificar y resolver el GR mediante el análisis de la gráfica ventilatoria.

Palabras clave: Asincronía paciente-ventilador; Respiración artificial; Cuidados críticos; Terapia respiratoria; Ventiladores mecánicos; Personal de salud; Educación en salud.

INTRODUCTION

Reverse triggering (RT) is a frequent type of patient-ventilator asynchrony (PVA) in patients with diminished respiratory drive connected to invasive mechanical ventilation. This PVA has been described as a reflex diaphragmatic contraction after passive insufflation started by the mechanical ventilator (MV) (1,2). The magnitude and duration of this reflex diaphragmatic contraction varies between respiratory cycles (2).

Some studies have documented a significant increase in transpulmonary pressure, airway driving pressure, plateau pressure, and lung volume redistribution to gravity-dependent pulmonary areas during RT (3-5). Evidence suggests that, in susceptible patients, PVAs such as RT can lead to the development of ventilation-induced lung injury; moreover, there is a higher association between repetitive patterns of this asynchrony and unfavorable clinical outcomes, including extended time on MV and mortality (6-8). It is still unclear which type of asynchrony has the

greatest impact on outcomes in patients on MV and which are the true outcome mediators. However, this has to be confirmed by studies designed to assess potential mediators of these negative outcomes (9).

Detection of this type of PVA through the analysis of the different curves provided by the ventilators is a major challenge for healthcare professionals working in intensive care units (ICU). In fact, the ability to identify RT reported by some studies is not greater than 59% (10-12). Moreover, among healthcare professionals, only 50% are able to correctly manage this type of PVA (10-12).

Despite potential complications associated with this type of asynchrony, there is currently a paucity of reports on the effects of training programs designed to help healthcare professionals acquire the competencies required to identify and resolve this type of PVA. The research group of which the authors of this study are members recently published a study which showed that a targeted program can improve the competencies for detecting

and addressing PVAs among ICU staff; however, analyses by asynchrony type were not carried out (10). Furthermore, the inclusion of professionals from different countries makes it difficult to recognize the specific training needs in each context. For this reason, the aim of this study was to conduct a subanalysis of both the immediate and 30-day effect of an education program specifically designed to detect and resolve RT through the analysis of the ventilation graph among Chilean professionals working in the ICU setting. To this purpose, the authors built on the data derived from the previous study (10).

METHODS

A secondary analysis was carried out based on the data used in a quasi-experimental study of the before-and-after type in which each of the participants was assessed at three different points in time (10-12). This research was approved by the ethics committee of Universidad de Chile Clinical Hospital (Page 1097/20). All of the

participants gave their informed consent for inclusion of their data in the analysis.

As part of the study, an education program aimed at improving detection and management of the different PVAs by critical care staff in Latin America and Spain was applied. The recruited professionals included 116 volunteer physicians, nurses and physical therapists (respiratory therapists or kinesiologists) of 20 hospitals from Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Peru, Spain and Uruguay.

Of the 36 hours comprising the program, 6 were dedicated to a synchronous on-line session through the *Zoom*® platform (Zoom Video Communications, San José, California) in which 120 real clinical cases of PVA were analyzed. For the remaining 30 hours, study participants were asked to devote one hour a day to personalized learning over the next 30 days.

A six-hour synchronous online session was divided into theory theme blocks covering the following content: 1) fundamentals of pressure/time, flow/time and volume/time curves (1 hour); 2) fundamentals, definitions and classification of PVAs (1 hour); 3) RT identification, causes and management (2 hours); 4) recognition, etiology and approach for other asynchronies associated with too little or too much flow (2 hours). After completing the session, the ICU professionals participated in daily meetings with the same instructor, during which they could ask questions and discuss real PVA cases observed in their hospitals. Additionally, during these online meetings, the instructor shared supplementary material such as scientific papers, clinical cases and videos for discussion at a later meeting. The main purpose of this training was to determine whether the competencies acquired during the initial session were maintained or even improved over time. For further details, see the study by Ramírez et al. (10).

An assessment tool designed by three experts in PVA was applied before and after the online session. Initial agreement was 83.3%, with disagreement found for

five of the questions, which were discussed until consensus was reached and then revised and validated. The assessment tool consisted of 30 multiple choice questions prepared in *Google Forms*® (Google, Mountain View, California). The aim of the questions was to assess the ability of the healthcare staff to recognize, determine the causes and resolve PVAs. Twenty of the questions showed MV images with pressure/time, flow/time and volume/time curves. The remaining ten questions were designed to assess basic concepts pertaining to PVAs. The same assessment tool was given to the participants 30 days after the online session, and the right answers were shared at the end of the study. The aim of this was to avoid the effect of learning by repetition.

Procedures

For this secondary analysis, only Chilean healthcare professionals who had participated in the study by Ramírez et al. (10-12) were included. All of the other inclusion and exclusion criteria were maintained: 1) having no formal education regarding PVAs; 2) working in an ICU at the time of the education program; 3) having to work with patients on mechanical ventilation as part of their job; and 4) submitting a validated certificate of their current work activity, specifying years of experience.

Information regarding the participants' performance with the questions designed to understand their ability to recognize RT and determine the right approach to manage this PVA was also extracted. Of the 30 questions in the assessment tool, two were aimed at assessing the ability to recognize RT and one was designed to determine the professional's ability to resolve it.

Statistical analysis

Absolute and relative frequencies were used to describe categorical variables, and

means with standard deviation or medians with interquartile ranges (IQR) were used for quantitative variables according to their distribution. The distribution of the quantitative variables was compared against the normal curve using the Shapiro-Wilk test.

Three outcome variables were considered for the inferential analysis: the first corresponds to the three grouped questions, the second covers the questions related to RT recognition, and the third focuses on the question pertaining to RT resolution. The chi-square test was used to compare the proportion of professionals who answered all the questions correctly before the online session (time T_0), following the online session (time T_1), and 30 days after the on-line session (time T_2). The same analysis was carried out by question type. A mixed effects model with simple logistic regression was also used to determine the probability of performance improvement among the participants in the study. Probabilities were presented as odds ratios (OR) with their respective 95% confidence intervals (95% CI). Alluvial diagrams were used to plot staff performance flows between T_0 - T_1 , and T_1 - T_2 .

Additionally, the impact of experience on performance was measured using a mixed effects model with multiple logistic regression, taking into consideration years of experience as a dichotomous variable, with a one-year cut-off point.

The JASP Version 0.19.2 computer software was used for the analysis, with a 5% level of statistical significance. The STATA 15.1 statistical software package (Copyright 1985-2017 StataCorp LLC) was used for the mixed effects model. The alluvial diagrams were prepared in RStudio (Version 2022.02.0+443, © 2009-2022 RStudio, PBC).

RESULTS

This secondary analysis included 49 professionals, accounting for 42.24% of

the participants included in the study by Ramírez et al. (10-12). Forty-six (93.88%) were physical therapists and the rest were nursing professionals. Median experience was three years (IQR 0.9 to 4), and 51.02% of the participants had less than one year of experience in critical care.

Correct answers to the three questions were given by 20.41% of the participants at time T_0 , a proportion which increased significantly at T_1 (73.47%) and T_2 (69.39%) ($p < 0.001$) (Table 1, Figure 1). As for the questions pertaining to RT identification, the proportion of participants who answered correctly increased significantly from 34.69% at time T_0 , to 81.63% and 73.45% at T_1 and T_2 , respectively ($p < 0.001$) (Table 1, Figure 2). Finally, the analysis of the question related to adequate RT management revealed that the proportion of participants who marked the right choice increased significantly from 59.18% at time T_0 , to 91.84% at T_1 , and 93.88% at T_2 ($p < 0.001$) (Table 1, Figure 3).

When adjusting for the effect of the education program on the ability to recognize and resolve RT, experience in years working in the ICU did not have a significant influence ($p < 0.001$) when considering the three questions.

DISCUSSION

This study describes the effect of a hybrid education program on the ability of Chilean healthcare professionals working in the ICU to identify and resolve RT based on ventilation curve analysis. This program enabled critical care professionals to improve their ability to recognize and resolve RT, regardless of experience. However, some of the healthcare professionals were unable to develop the skills to identify and manage this PVA.

In recent years, various types of complications associated with the different PVAs have been identified. Some of the deleterious clinical consequences of PVA are more days on MV, dyspnea, pulmonary and diaphragmatic injury, delayed weaning, and

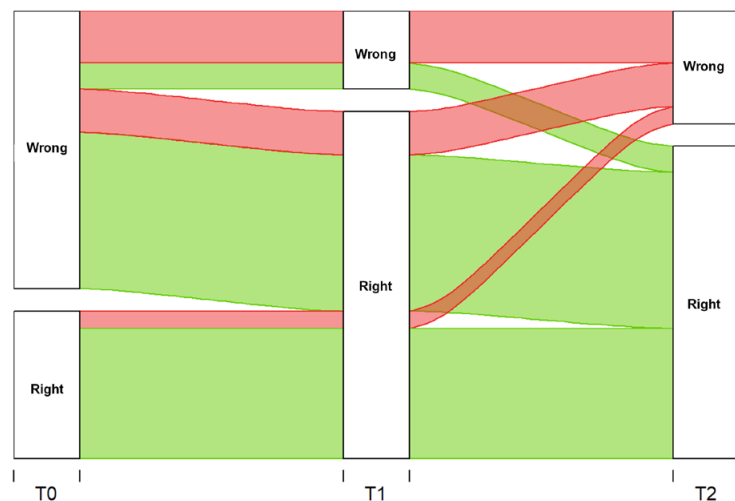
Table 1. Odds ratios for improvement in RT recognition and management.

	Reference	Time of assessment	
		T_1	T_2
All questions	T_0	32.13 (6.81 to 151.66)	24.14 (5.47 to 106.42)
Identification questions	T_0	38.78 (6.87 to 218.97)	17.65 (3.94 to 79.02)
Management questions	T_0	17.21 (3.07 to 96.45)	25.17 (3.82 to 165.69)

T_0 : before the online session, T_1 : after the online session, T_2 : 30 days after the online session. Values are presented as OR (95% CI).

Source: Authors.

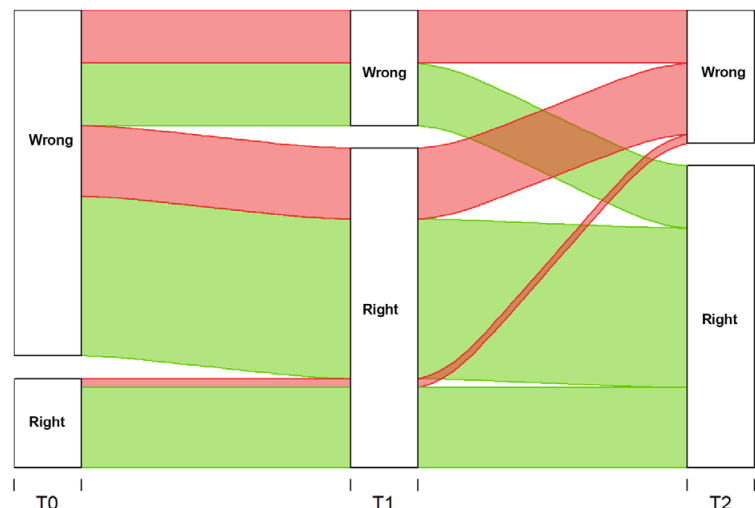
Figure 1. Alluvial diagram of participant performance in the three questions (RT recognition and resolution) at T_0 , T_1 and T_2 .



T_0 : before the online session, T_1 : after the online session, T_2 : 30 days after the online session.

Source: Authors.

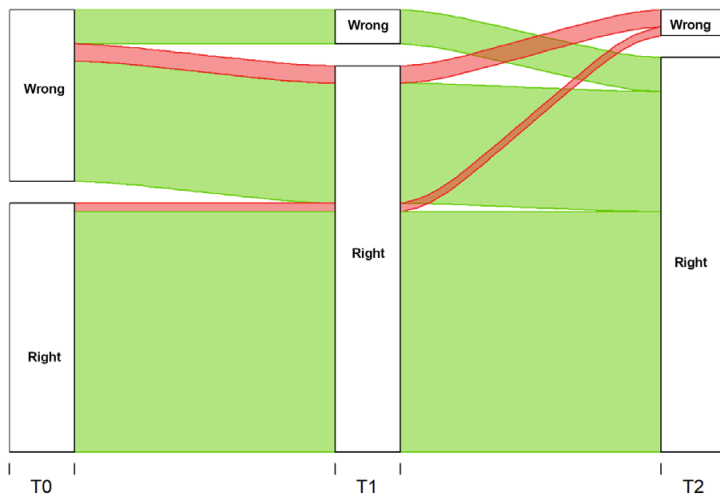
Figure 2. Alluvial diagram of participant performance regarding the questions on RT recognition at T_0 , T_1 and T_2 .



T_0 : before the online session, T_1 : after the online session, T_2 : 30 days after the online session.

Source: Authors.

Figure 3. Alluvial diagram of participant performance in relation to the question on RT resolution at T_0 , T_1 and T_2 .



T_0 : before the online session, T_1 : after the online session, T_2 : 30 days after the online session.

Source: Authors.

higher in-hospital mortality (7,8,13-15). This highlights the importance of recognizing and addressing the different PVAs which occur in critically ill patients. Despite a growing number of training programs focusing specifically on the recognition and management of PVAs such as RT, few studies have reported their effects.

Initially described by Akouminiaki et al. (16) in 2013, RT manifests as a secondary reflex diaphragmatic contraction in response to passive insufflation by the MV in patients under deep sedation, and even in patients diagnosed with brain death (17). The intensity and duration of the reflex diaphragmatic contraction varies; in some cases it leads to an increase in transpulmonary pressure, airway driving pressure, overdistension of gravity-dependent lung zones, and pulmonary and diaphragmatic injury (1-5).

RT identification and management using pressure/time and flow/time curves requires highly trained healthcare professionals. RT recognition requires evidence of a negative inflection in the pressure/time curve during the trigger

phase. However, as it is an MV-triggered reflex, some authors suggest that an expiration pause should be applied in order to identify RT (18), looking for the absence of inspiratory effort on the pressure/time curve to determine that the patient is indeed experiencing RT (18). Different strategies have been proposed for the management of RT, the most frequently reported being to increase support levels, lower respiratory rate, and use neuromuscular blockers (1,4,5,19).

In response to PVA-associated complications, several authors have focused their efforts on assessing the ability of healthcare practitioners to detect and resolve them using ventilation graph analysis (10-12,20-27). Surprisingly, several studies have shown that less than 30% of the healthcare professionals are capable of identifying different types of PVA correctly (20-28). On the other hand, only 12.5% are able to adequately address different types of PVAs (21). In this study, only 34.69% of the participants adequately identified RT while 59.18% resolved it; however, only 20.41% were capable of answering the

three questions correctly. After completing the 6-hour online synchronous training, there was a considerable increase in the percentage of professionals who identified and resolved RT correctly, to 81.63% and 91.84%, respectively. Moreover, there were no significant changes between the assessment carried out upon completion of the synchronous phase and the 30-day post-training assessment. Similar results had been previously obtained by Gravante et al. (29). Nursing students showed a significant improvement in their ability to identify asynchrony during the two post-education phases. Similarly, there was no significant increase in the percentage of PVA detection between the immediate and the 30-day post-training assessment. However, unlike the study by Gravante et al. (29), this study did not only assess the ability to detect a specific type of PVA — RT in this case — but also the ability to resolve it. Additionally, this education program considered one-hour daily sessions with the instructor during the 30 days following the online session. This strategy may have contributed to maintain the level of RT recognition and resolution. Moreover, it was also shown, for the participants in this study, that years of experience is not a determinant of the ability to correctly identify or solve RT.

In this study, sample size and selection, as well as the inability to confirm some inclusion criteria and the lack of control variables in the multiple regression analysis, are limitations when it comes to establishing a causal relationship between the participation in the education program and improved RT detection and resolution. These methodological considerations should be taken into account in future studies. Furthermore, participant distribution by profession was asymmetrical, perhaps limiting the ability to generalize the results. As far as professions are concerned, 93% of the participants were physical therapists, while 7% were nurses. Another limitation is the absence of physicians among the participants, given that in most clinical settings, it is physicians who are responsible

for MV. Importantly, though, in Chile as well as in other Latin American countries, physical therapists, respiratory therapists or kinesiologists have a specific training level that allows them to manage ventilation therapy together with the medical staff. On the other hand, the absence of a control group can be considered a limitation but, indeed, individual participants were used as their own controls.

Notwithstanding these limitations, the findings reported herein point to the need for ICU professionals to receive constant training on the identification and resolution of PVAs such as RT. Moreover, even with 36 hours of specific training during one month, not all the participants were able to provide correct answers to the evaluation questions (30). In this context, automatic PVA detection algorithms could solve the problem (31-33). However, this technology might not be available everywhere, particularly in low-income settings. A highlight of this study is that the education program was carried out online. This modality allows professionals from different places to participate, without having to spend financial resources in travel to other cities or countries to gain access to this type of training. Additionally, tutoring and daily follow-up during a specific time period create opportunities to improve and apply the acquired knowledge on a daily basis.

CONCLUSIONS

Attending a specific education program focusing on PVA recognition and resolution could help critical care healthcare professionals in Chile, regardless of their experience, to improve their ability to recognize and solve RT based on ventilation graph analysis.

Further research is needed in order to gain an insight into the long-term impact of training programs similar to the one used in this study, and also to determine

the potential effect of better prepared professionals on various clinical outcomes in patients on invasive MV.

ETHICAL RESPONSIBILITIES

Ethics committee approval

The study was approved by the ethics committee of the Universidad de Chile Clinical Hospital (Page 1097/20).

Protection of human and animal subjects

No experiments were performed on humans or animals for this study.

Data confidentiality

Only the study researchers have access to databases that contain information regarding the identification of the participating professionals.

Right to privacy and informed consent

Participant data have remained anonymous at all times, and the informed consent was obtained from all the participants in the study.

ACKNOWLEDGEMENTS

Authors' contributions

IRV: Conceptualization, data preservation, research, methodology, project management, supervision, validation and writing of the original draft.

RG-A: Data preservation, formal analysis, methodology, visualization and writing (review and editing).

Assistance for the study

None declared.

Financial support and sponsorship

None declared.

Conflict of interest

None declared.

Presentations

This study built on the data used in two previous publications and a presentation at a congress:

- Effect of a specific training program on patient-ventilator asynchrony detection and management. Scientific letter published in the Intensive Medicine journal (12).
- Specific training improves the detection and management of patient-ventilator asynchrony. Original article published in Respiratory Care (10).
- KI-3: Un programa de formación específico mejora la detección, el manejo y la determinación de la causa de las asincronías paciente-ventilador. Work presented orally during the XXII National Kinesiology Congress (CONAKI) 2023, Santiago, Chile (11).

In none of the three studies mentioned above were results presented separately by country or was the focus a specific PVA.

Appreciation

None declared.

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