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Original Article

Assessment of asynchronies on pressure time product (PTP) in active pediatric patients

Pediatrik aktif hastalarda asenkroninin basınç zaman ürününe etkisinin (PTP) değerlendirmesi

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ABSTRACT

Aim: To reveal the effect of synchronous or asynchronous patients on these values by examining the esophageal pressure (Pes), transpulmonary pressure (PL), and time-pressure-product (PTP) in active patients who are planned to be weaned from the mechanical ventilator and can trigger their own respiration.

Material and Methods: Patients who are monitored on a mechanical ventilator and who can trigger their own respiration, and who are planned to be separated from the mechanical ventilator in the near future, were taken and an esophageal catheter was inserted, then the catheter filling volume was first optimized and then validated, and PL was started to be recorded by removing Pes from the airway pressure. With the recording devices on the ventilator, the mechanical ventilation parameters of the patients were recorded as both monitoring values and waveforms. Then, the mechanical ventilation settings were rearranged by the clinician at the bedside with reference to the esophageal waveform. Then, the waveforms of these patients have examined on the Matlab E2019a (Mathworks, USA) software, and each breath was marked as synchronous-asynchronous and the asynchrony index (AI) was calculated. Accordingly, the asynchronous and synchronous periods of the patient were defined, and the values of ΔPes, ΔPL, PTP-Pes, PTP-PL, PTP-Pes-minutes, PTP-PL-minutes between the synchronous and asynchronous periods of the same patient were calculated on Matlab software, and synchronous and The changes in these values between asynchronous periods were analyzed with the SPSS statistical program. After examining the distribution of the variables by visual and analytical methods (Shapiro-Wilk), the statistical difference between the groups was examined.

Results: When the synchronous and asynchronous periods of all patients were compared, the following differences were found between the synchronous and asynchronous groups in favor of the synchronous group. ΔPes [3.6 (2.9-4.2)] cmH2O, ΔPL [3.1 (2.5-4]cmH2O, ΔPTP-Peso [3.6 (2.8-4.6))]cmH2O*s, ΔPTP-PL [5.1 (3.6-7.7)]cmH2O*s, ΔPTP-Peso/min [1.8 (1.3-2.5)] cmH2O*min , ΔPTP-PL/min [1.3 (0.4-2.3)]cmH2O*min.

Conclusion: It has also been shown by statistical analyzes that the synchronization of active patients who are planned to be weaned from mechanical ventilator and who can trigger their own respiration causes a decrease in the values of ΔPeso, ΔPtranspulmonary, PTP-Peso, PTP-Ptranspulmonary, PTP-Peso-minute, PTP-Ptranspulmonary-minute. When this information about synchronization is correlated with the literature, Pes monitoring in patients and synchronization of patients prevent mechanical ventilation-related lung damage that may occur in these patients, and thus the duration of hospital stay due to asynchrony, failure to wean from the ventilator, and the consequences that may occur. It may be a method that can be useful in reducing mortality and morbidity.

Keywords: esophageal pressure (PES); transpulmonary pressure (PL); pressure time product (PTP)

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Öz

Amaç: Mekanik ventilatörden ayrılması planlanan ve kendi solunumlarını tetikleyebilen aktif hastalarda özefageal basınç (Pes), transpulmoner basınç (PL) ve zaman-basınç-ürününü (PTP) inceleyerek hastaların senkron veya asenkron oluşunun bu değerlere etkisini ortaya koymak.

Gereç ve Yöntemler: Çalışmamıza mekanik ventilatörde izlenen ve kendi solunumunu tetikleyebilen, yakın zamanda mekanik ventilatörden ayrılması planlanan hastalar alınarak özefageal kateter yerleştirilmiş, ardından kateter dolum hacmi önce optimize ardından valide edilerek önce Pes ardından havayolu basıncından Pes'ın çıkarılmasıyla PL kayıt edilmeye başlanmıştır. Ventilatör üzerindeki kayıt cihazlarıyla hastaların mekanik ventilasyon parametreleri hem monitörizasyon değerleri hem de dalga formları olmak üzere kayıt altına alınmıştır. Daha sonra hasta başında klinisyen tarafından mekanik ventilasyon ayarları özefageal dalga formu referans alınarak yeniden düzenlenmiştir. Ardından bu hastaların dalga formları Matlab E2019a (Mathwoks, USA) yazılımı üzerinde incelenerek her soluk senkron-asenkron olarak işaretlenmiş ve asenkroni indeksi (AI) çıkarılmıştır. Buna göre hastanın asenkron ve senkron dönemleri tanımlanmış, aynı hastanın senkron ve asenkron dönemleri arasında ΔPes, ΔPL, PTP-Pes, PTP-PL, PTP-Pes-dakika, PTP-PL-dakika değerleri yine Matlab yazılımı üzerinde hesaplanarak, senkron ve asenkron dönemler arasında bu değerlerin değişimleri SPSS istatistik programı ile incelenmiştir. Değişkenlerin dağılımının görsel ve analitik yöntemlerle (Shapiro-Wilk) incelenmesinin ardından istatiksel olarak gruplar arası farka bakılmıştır.

Bulgular: Tüm hastaların senkron ve asenkron dönemleri kıyaslandığında senkron ve asenkron gruplar arasında, senkron grup lehine şu farklar bulunmuştur. ΔPes [3.6 (2.9-4.2)] cmH2O, ΔPL [3.1 (2.5-4]cmH2O, ΔPTP-Peso [3.6 (2.8-4.6))]cmH2O*s, ΔPTP-PL [5.1 (3.6-7.7)]cmH2O*s, ΔPTP-Peso/d [1.8 (1.3-2.5)]cmH2O*d , ΔPTP-PL/d [1.3 (0.4-2.3)]cmH2O*d

Sonuç: Mekanik ventilatörden ayrılması planlanan ve kendi solunumunu tetikleyebilen aktif hastaların senkronizasyonunun hastaların ΔPeso, ΔPtranspulmoner,PTP-Peso,PTP-Ptranspulmoner,PTP-Peso-dakika, PTP-Ptranspulmoner-dakika değerlerinde düşüşe yol açtığı yapılan istatistiki analizlerle de gösterilmiştir. Senkronizasyona dair bu bilgi litratürle korele edildiğinde, hastalarda Pes monitörizasyonu ve hastaların senkronizasyonu sözkonusu hastalarda oluşabilecek olan mekanik ventilasyon ilişkili akciğer hasarını önlemede ve dolayısıyla asenkroniye bağlı hastanede kalış süresi, ventilatörden ayırma başarısızlığı ve bunların sonucunda gelişebilecek olan mortalite ve morbiditeyi azaltmada faydalı olabilecek bir yöntemdir.

Anahtar Kelimeler: özefageal basınç; transpulmoner basınç; basınç zaman ürünü

Introduction

In order to understand the lung mechanics in a mechanically ventilated patient, esophageal pressure measurement is the gold standandart[1]. However, this method has been accepted since 1949[2] because of difficulties at bedside, the number of centers using this method are limited [3]. Additionally, considering that this method is the gold standard in showing the patient-diaphragm-ventilator relationship and the asynchronies that occur during mechanical ventilation might increase the mortality of patients, it is inevitable to use this method for the examination of both asynchrony and lung mechanics[4-6]. In our study, our aim was to examine the esophageal pressure (Pes), transpulmonary pressure (PL) and time-pressure-product (PTP) in active patients who are planned to be weaned from mechanical ventilator and who can trigger their own respiration, to reveal the effect of synchronous or asynchronous periods on these values.

Material and Methods

Our study was carried out in İzmir Dr. Behçet Uz Children's Hospital Pediatric Intensive Care Clinic. This center, which has 24 tertiary level intensive care beds, is the reference children's hospital for the province and its surroundings. In order to conduct this study, necessary ethical approval was obtained from the relevant institutions. Informed consent documents were obtained from the patients participating in the study, and the study was conducted in accordance with the Helsinki declaration and good clinical practices. Our study included patients between the ages of 1 month and 18 years, whose breathing was supported by mechanical ventilation and who could trigger their own breaths between November and December 2020. All the patients were ventilated with Hamilton-G5 mechanical ventilators. Airway pressure and flow were measured by the ventilator's proximal pneumotachograph (single-use flow sensor,

PN281637, Hamilton Medical AG, Bonaduz, Switzerland, linear between -180 and +180 l/min with a +15% error of measure) inserted between the endotracheal tube and the Y-piece[7]. Volume was obtained by integration of the flow signal. CO2 was measured with the ventilator's mainstream CO2 sensor (Capnostat5, PN281718) using the adult/pediatric airway adapter with a dead-space volume of 5 ml [8].

Esophageal catheter was placed in 13 patients who were planned to be weaned from the mechanical ventilator in the foreseeable future [9-10]. After this procedure, the catheter filling volume was first optimized. Subsequently, the catheter location was also validated [4]. Pes values were recorded first. transpulmonary pressure (PL) was started to be recorded by subtracting the Pes from the airway pressure [11-12]. With the recording devices on the ventilator, the mechanical ventilation parameters of the patients were recorded as both monitor values and waveforms. Then, the mechanical ventilation settings were rearranged by the clinician at the bedside with reference to the esophageal waveform. Then, the waveforms of these patients were examined on the Matlab E2019a (Mathwoks, USA) software, and each breath was marked as synchronous-asynchronous and the asynchrony index (AI) was calculated. Accordingly, the asynchronous and synchronous periods of the patient were defined, and the values of ΔPes, ΔPL, PTP-Pes, PTP-PL, PTP-Pes-minutes, PTP-PL-minutes between the synchronous and asynchronous periods of the same patient were calculated on Matlab software. The changes in these values between synchronous and asynchronous periods were analyzed with the SPSS statistical program. After examining the distribution of the variables by visual (histogram) and analytical methods (Shapiro-Wilk), the statistical difference between the groups was again examined. In addition, these values were compared with the Wilcoxon-Rank test. A p value of < 0.005 was accepted as statistically significant.

Results

13 patients were included in our study. The ratio of female cases to all cases in the study was 46%. When the mechanical ventilation reasons of the patients were examined, it was determined that 3 of them were hospitalized for respiratory reasons, 3 of them were hospitalized in the pediatric intensive care ward for cardiovascular reasons, 2 of them for renal metabolic reasons, and the rest for other reasons. The mean PLIS scores of the patients were found to be 2.6. Again, the PIM3 scores of these patients indicated a predicted mortality of 46%. The synchronous and asynchronous periods of the patients were compared and the analyzes showed that there was a significant decrease in all parameters (ΔPes, ΔPL, PTP-Pes, PTP-PL, PTP-Pes-minutes, PTP-PL-minutes) in the synchronous group compared to the asynchronous group. (Figure 1). When the synchronous and asynchronous periods of all patients were compared, the following differences were found between the synchronous and asynchronous groups in favor of the synchronous group. ΔPes [3.6 (2.9-4.2)] cmH2O, ΔPL [3.1 (2.5-4]cmH2O, ΔPTP-Peso [3.6 (2.8-4.6))]cmH2O*s, ΔPTP-PL [5.1 (3.6-7.7)]cmH2O*s, ΔPTP-Peso/min [1.8 (1.3-2.5)]cmH2O*min , ΔPTP-PL/min [1.3 (0.4-2.3)]cmH2O*min. In addition, these values were compared with the Wilcoxon-Rank test and all of them were statistically significant

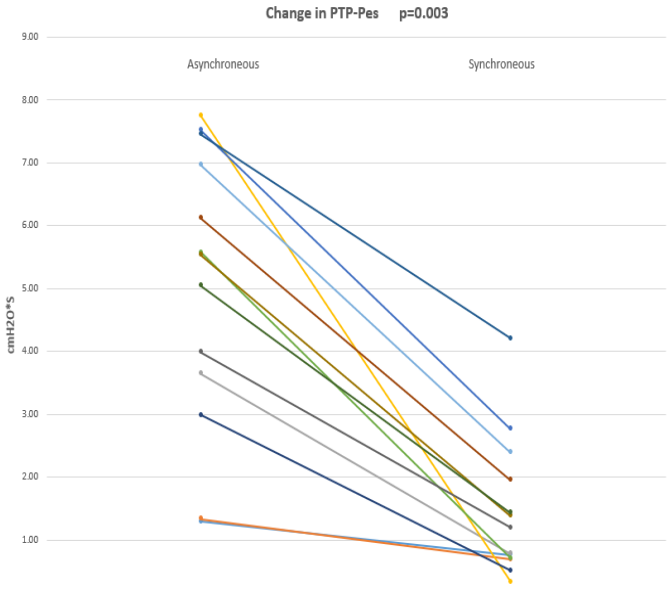

Figure 1. Esophageal pressure – pressure time product (PTP-Pes) changes during asynchronous and synchronous periods of invasive mechanical ventilation in pediatric patients.

Discussion

It has been shown that the synchronization of active patients who are planned to be weaned from mechanical ventilators and who can trigger their own respiration, leads to a decrease in ΔPes, Δ PL, PTP-Pes, PTP- PL, PTP-Pes-minutes, PTP-PL-minutes of patients. This information suggests that some of the mechanical ventilation-related lung and diaphragm damage in the literature can be prevented by patient synchronization.

The troublesome and expensive nature of the application of this method precluded the increase in the number of samples in the study. It may be useful to repeat the study with more cases. Apart from this, the fact that the study was conducted in a single center is another limitation.

Conclusion

In patients who may potentially develop respiratory system damage due to mechanical ventilators, firstly, synchronization and the use of esophageal pressure monitoring in necessary cases may increase the rates of weaning from the ventilator and shorten the hospital stay. As a result of these improvements, it may also be beneficial to reduce mortality and morbidity.

Declaration of conflict of interest

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. Gokhan Ceylan is the only author with a conflict of interest, he is employed by Hamilton Medical AG in the Department of Medical Research. None of the other authors have a conflict of interest.

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