GEORGIAN MEDICAL NEWS

ISSN 1512-0112

N0 9 (330) Сентябрь 2022

ТБИЛИСИ - NEW YORK

ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

Monthly Georgia-US joint scientific journal published both in electronic and paper formats of the Agency of Medical Information of the Georgian Association of Business Press. Published since 1994. Distributed in NIS, EU and USA.

GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.

GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.

ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

Articles that Fail to Meet the Aforementioned Requirements are not Assigned to be Reviewed.

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**, ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ, რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

GEORGIAN MEDICAL NEWS
No 9 (330) 2022

Содержание:

GEORGIAN MEDICAL NEWS
No 9 (330) 2022

RESPIRATORY MUSCLES FUNCTION IN CHILDREN 6-18 YEARS OLD WITH ACUTE HYPOXEMIC RESPIRATORY FAILURE: THE PROSPECTIVE OBSERVATIONAL COHORT STUDY

Olha Filyk[1], Yaroslav Pidhirnyi[1].

[1]*Danylo Halytsky Lviv National Medical University, Lviv, Ukraine.*

Abstract.

Background: Acute respiratory failure due to pneumonia is a significant cause of death in children 6-18 years old.

Objective: To find out whether diaphragm dysfunction might lead to unsuccessful weaning from MV in children 6-18 years old.

Materials and methods: We provided prospective observational cohort study and included 104 patients, who were splitting in the study and the control groups and 2 age subgroups. To consider diaphragm function, we check amplitude of its movement and diaphragm thickening fraction (Dtf).

The primary outcome was the incidence of successful weaning from MV. The secondary outcomes were changes in diaphragm function parameters.

Results: Dtf for right hemidiaphragm was significantly lower in the study group 1st subgroup on day 1 and day 5, and significantly higher on day 14 ($p<0.05$), while for left hemidiaphragm it was significantly higher on day 1 and lower on day 5 compared with the control group ($p<0.05$). In 2nd subgroup Dtf was significantly higher for both sides in the study group on day 1 compared with the control group ($p<0.05$).

Amplitude of diaphragm movement was significantly decreased in 1st subgroup of the study group on day 1 and day 5 and increased on day 14 compared with the control group ($p<0.05$).

The incidence of successful weaning from MV in the study group was significantly lower compared with the control group.

Conclusions: Diaphragm dysfunction might alter weaning from MV in children 6-18 years old.

Key words. Respiratory physiology, diaphragm, respiratory failure, children.

Introduction.

Diaphragm dysfunction is common in mechanically ventilated patients and predisposes them to prolonged ventilator dependence and poor clinical outcomes [1]. This fact was confirmed for adult patients and therefore diaphragm ultrasound becomes a daily routine investigation when patient is ready for decreasing mechanical ventilation (MV) parameters what means weaning from MV. Significantly, it has been observed that similar pathophysiology changes are present in pediatric patients, who need to be mechanically ventilated [2,3]. In the last decades we observed the improvement in the treatment of pediatric acute respiratory failure [2], and the mortality rates in children aged under 5 years have steadily declined in the WHO European Region in recent years, however, children are still dying from pneumonia [4]. There are guidelines on oxygen therapy for children [5], mechanical ventilation of critically ill children [6,7], nevertheless, there is no evidence that diaphragm dysfunction leads to complicated weaning from MV in children under 5 years old and how clinicians might improve clinical outcome in case of confirmed diaphragm dysfunction in child who is mechanically ventilated. The process of breathing is the work performed by the respiratory muscles, in particular the diaphragm. Exhaustion of such muscles leads to the impossibility of maintaining the proper level of breathing, and therefore, can lead to the persistence of respiratory insufficiency and complicate the process of weaning from mechanical ventilation. To confirm or deny the statement that diaphragm dysfunction impact weaning from mechanical ventilation we choose the study hypothesis that presence of diaphragm dysfunction might lead to unsuccessful weaning from respiratory support in children with acute respiratory failure.

Aim.

The aim of the study was to find out whether diaphragm dysfunction in patients with acute respiratory failure might lead to unsuccessful weaning from MV.

Materials and methods.

We provided prospective observational cohort study at the Department of Anesthesiology and Intensive Care, Danylo Halytsky Lviv National Medical University; Department of Anesthesiology and Intensive Care, Lviv Regional Children Hospital "OCHMATDYT" which included 104 patients 6 – 18 years old. There were 61 patients (study group) with acute respiratory failure who need to be provided with MV and 43 patients (control group) who underwent MV during elective surgeries and were weaned immediately after it were held. The main differences between the control and study groups were indications for mechanical ventilation. Patients without respiratory diseases and signs of acute respiratory failure were included in the control group, and they underwent mechanical ventilation during general anesthesia. The study group included those patients in whom the presence of acute respiratory failure was confirmed by clinical, laboratory, and instrumental examination methods, and mechanical ventilation was performed as a component of acute respiratory failure treatment. The control group of patients included children who underwent adenotonsillectomy, and the duration of ventilatory support did not exceed 80 minutes. In the study group there were included patients who were mechanically ventilated for more than 3 days due to severe bilateral community acquired pneumonia. The inclusion criteria for the study group were: paO_2 less than 60 mm Hg at high-flow nasal oxygen therapy, paO_2/FiO_2 ratio less than 250, shortness of breath more than 50% of the upper limit of the age-standard respiratory rate. Exclusion criteria for both groups were: the refusal of the patient's legal representatives to participate in the study at any of its stages, the patient's agonizing state upon admission, and the onset of MV less than 48 h after prior weaning. Both groups` patients received lung-protective ventilation strategy.

The study was conducted in accordance with the requirements of good clinical practice, the Council of Europe Convention on Human Rights and Biomedicine, the Helsinki Declaration of the World Medical Association. The study was approved by the Bioethics Commission of Danylo Halytsky Lviv National Medical University, protocol №1, January 30, 2018. All patients` relatives or their legal representatives signed informed consent to participate in the study.

All patients were splitting in 2 age subgroups: 1st – 6 - 12 years old, 2nd – 13 - 18 years old. Patients were divided into age subgroups to take into account their age-related anatomical and physiological characteristics, in particular, the respiratory rate, lung compliance, chest elasticity. In our study, we do not present an analysis of changes in these indicators during the treatment course, however, the dynamics of these data were important in deciding on the duration of mechanical ventilation and initiation of weaning from it.

To check the diaphragm function, we provided ultrasonography of diaphragm during respiration and consider its amplitude of movement, diaphragm thickening fraction (Dtf), inspiratory time for both right and left hemidiaphragms. The primary outcome was the incidence of successful weaning from MV. The secondary outcomes were changes in diaphragm function parameters, which made the confirmation of the diaphragm dysfunction diagnosis. It was the amplitude of diaphragm movement (and decreasing less than 8 mm was a marker of under-assistance during MV, increasing over 15 mm was a marker of over-assistance during MV), and the diaphragm thickening fraction (decreasing less than 15% was a marker of diaphragm weakness and its increasing up to more than 35% was a marker of high respiratory function and a potentially damaging diaphragm factor).

Stages of the study: 1st day - for both groups and 5th day, 7th day, 14th day - for the study group only.

Statistical analysis of the study results was performed using MS Excel 2017 with the calculation median [IQR - interquartile range], the level of significance p with Kruskal-Wallis test. A p-value less than 0.05 vas taken as statistically significant. Sample size calculations for our hypothesis resulted in 21 patients per group. We used a type 1 error of $\alpha = 0.05$ and a power of 0.80 to calculate the sample sizes (G*Power version 3.3.9.4).

Results.

All participants completed the study protocol. For demographical data see Table 1. No adverse events were observed during the study. Diaphragm ultrasound data showed significant reduction of ventilator-patient asynchrony and, in addition, reduction the need in deep sedation after beginning weaning from MV in both groups but not significant difference between groups.

Diaphragm thickening fraction: Results are presented as median with IQR. Dtf for right hemidiaphragm was significantly lower in the study group 1st subgroup on day 1 and day 5 compared with the control group ($p<0.05$), and significantly higher on day 14 ($p<0.05$). On the other hand, for left hemidiaphragm Dtf in the study group was significantly higher on day 1 and significantly lower on day 5 compared with the control group ($p<0.05$) (Figure 1).

In 2nd subgroup Dtf was significantly higher for both right and left hemidiaphragms in the study group on day 1 compared with the control group ($p<0.05$) (Figure 2), while on day 5 and day 14 data were in normal reference ranges with no significant differences between groups.

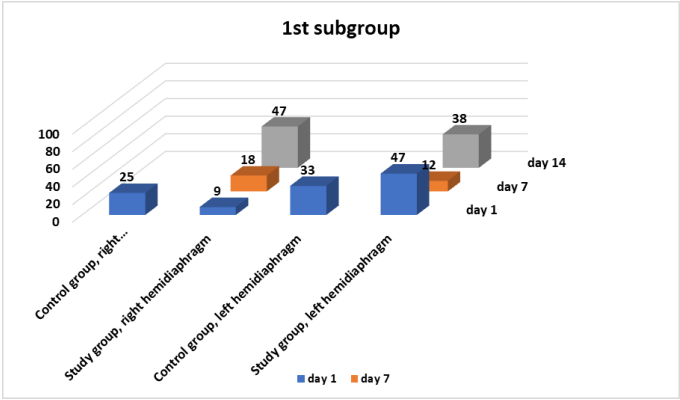

Figure.1. *Data showing Dtf for the study and the control groups in 1st subgroup.*

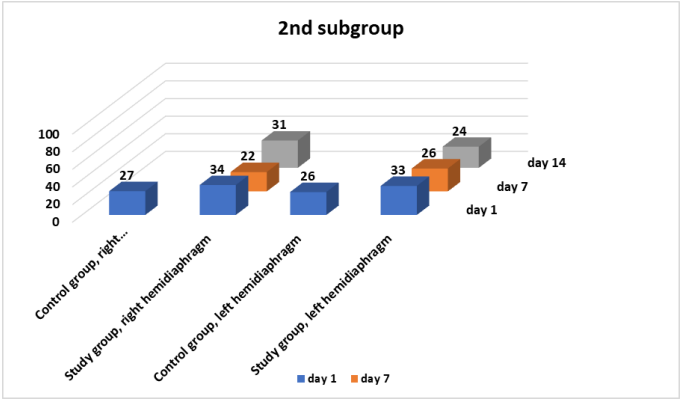

Figure. 2. *Data showing Dtf for the study and the control groups in 2nd subgroup.*

In analysis of incidence of the absence the spontaneous movements of diaphragm in study group, 2 out 22 patients in the 1st subgroup, 4 out 39 patients in 2nd subgroup have this deterioration on day 1. No such kind changes were observed on next study stages.

Amplitude of diaphragm movement: Results are presented as median with IQR. We have made the analysis of data on right and left sides, they were very close to each other for every patient, therefore we present arithmetic means for right and left sides diaphragm movement amplitude.

No statistically significant differences in amplitude of diaphragm movement were found between groups in 2nd subgroup at all study stages (Table 2).

The amplitude of diaphragm movement was significantly decreased in the study group 1st subgroup on day 1 and day 7 ($p<0.05$), and significantly increased on day 14 compared with the control group ($p<0.05$) (Table 2). In addition, this

Table 1. *Personal data.*

	Group (subgroup), n			
	Study (1st), n=22	**Study (2nd), n=39**	**Control (1st), n=21**	**Control (2nd), n=22**
Sex (male/female)	14/8	24/15	7/8	8/8
Age (years)	8 [6; 11]	14 [13; 17]	9 [6; 12]	15 [13; 18]
Height (cm)	118 [112; 121]	151 [142; 156]	115 [111; 120]	155 [152; 159]
Weight (kg)	22 [21; 25]	48 [42; 51]	27 [24; 29]	51 [45; 54]
BMI, kg/m^2	15,5 [14,8; 17,1]	20,9 [18,8; 22,1]	19,8 [18,5; 21,5]	21,1 [20,4; 23,1]

Data presented as median with IQR or numbers when applicable.

Table 2. *Changes in diaphragm movement amplitude for the study and the control groups.*

Data	**Subgroup**	**Group, study stage**					**P**
		Control, day 1	Study, day 1	Study, day 5	Study, day 7	Study, day 14	
Amplitude of diaphragm movement, arithmetic means for right and left sides, mm	**1st**	9 [8; 10]	4 [2; 6]	7 [6; 8]	9 [7; 11]	15 [11; 18]	0,05
	2nd	11 [8; 12]	9 [6; 11]	11 [6; 12]	12 [8; 15]	14 [8; 16]	0,18

Table 3. *The successful weaning from MV incidence in the control and the study groups.*

Data	**Subgroup**	**Group, study stage**					**P**
		Control, day 1	Study, day 1	Study, day 5	Study, day 7	Study, day 14	
Count of successfully weaned from MV patients/ total patients` count	**1st**	15/15	0/22	4/22	12/22	20/22	0,04
	2nd	16/16	0/39	12/39	26/39	32/39	0,02

parameter had the tendency for increasing during the study for all subgroups of the study group. For 1st subgroup it increased from 4 [2; 6] mm on day 1 to 7 [6; 8] on day 5; 9 [7; 11] mm on day 7, and to 15 [11; 18] mm on day 14, while in 2nd subgroup from 9 [6; 11] mm on day 1 to 11 [6; 12] on day 5; 12 [8; 15] on day 7 and to 14 [8; 16] mm on day 14.

According to the obtained data, it could be stated that diaphragm dysfunction was detected in study group 1st subgroup on day 1 and day 5 with data about insufficient diaphragm load and on day 14 with data about diaphragm overload. Also, we found subclinical diaphragm overload in study group 2nd subgroup on day 14.

In the current study, there were found that the incidence of successful weaning from MV was 100% for the day 1 in the control group, while in study group the incidence was significantly lower (Table 3). In 1st subgroup successfully weaned from MV on day 14 were 20 out 22 patients (91%), in 2nd subgroup – 32 out 39 patients (82%). However, on day 1 – no one from the study group was weaned (0%), on day 5 - 4 out 22 patients in 1st subgroup (18%), 13 out 39 patients (33%) in 2nd subgroup; on day 7 – 12 out 22 patients in 1st subgroup (55%), 26 out 39 patients (67%) in 2nd subgroup ($p<0.05$).

Discussion.

In this prospective observational cohort study, we hypothesized that diaphragm dysfunction might lead to unsuccessful weaning from respiratory support in children with acute respiratory failure. The results showed that the presence of diaphragm dysfunction was significantly higher in patients with acute hypoxemic respiratory failure compared with healthy individuals of the same age.

The diaphragm is the primary muscle of inspiration and therefore crucially determines the patient's ability to sustain ventilation in the face of respiratory loads (acute or chronic). By prolonging ventilator dependence, dysfunction predisposes to further diaphragm atrophy and injury, to nosocomial complications (ICU-acquired weakness, nosocomial sepsis, so on), and to a higher risk of long-term morbidity and mortality [1]. It is well known that acute respiratory failure might lead to self-inflicted lungs injury [8] and diaphragm myotrauma [9] therefore the role of spontaneous breathing among patients with acute hypoxemic respiratory failure is debated. On the other hand, there is no possibility to achieve readiness for weaning from MV without continuous training with increasing spontaneous breathing efforts and decreasing mechanical respiratory support. And the balance among these two processes is crucial in surviving patients and as soon as possible weaning from MV. Consequently, diaphragm ultrasound helps to check diaphragm function is highly important modern tool in ICU. Our study adds the important information that the presence of diaphragm dysfunction worsens clinical outcome due to decreasing the incidence of successful weaning from MV. These results might be expected beforehand, since data from previous studies in adult patients were published, where was established that diaphragm weakness can impact survival and increases comorbidities in ventilated patients [10]. Mechanical ventilation is linked to diaphragm dysfunction through several mechanisms of injury, referred to as myotrauma. By monitoring diaphragm activity and titrating ventilator settings, the critical care clinician can have a direct impact on diaphragm injury [1].

Based on the results of this study, it seems that good diaphragm contraction quality with enough level of its movement amplitude facilitates smooth and quick liberation from respiratory support. So, the amplitude of diaphragm movement from 9 [8; 10] mm in 1st subgroup of the control group, 11 [8; 12] mm in 2nd subgroup of the same control group give 100% of successful weaning on day 1. Of course, these were patients with good lung compliance unlike the study group, where patients need to do high respiratory muscles` work to maintain gas exchange in case of low lung compliance. The reason for lower incidence of weaning from MV till day 14 in 1st subgroup of the study group might be in pathophysiological features of respiratory system due to pneumonia. It is difficult to achieve a good level of ventilator-patient interaction due to psychological issues which lead to patient-ventilator asynchrony with excessive muscles work, what have the confirmation in high level of amplitude of diaphragm movement on 14 day in 1st subgroup study group with the high level of Dtf on the same day 14, when the median for right side was 47% and for the left side - 38%. The theoretical confirmation of harmfulness the under assistance myotrauma are study about the effects of both chronic and acute load-induced diaphragm injury which have been demonstrated by muscle biopsies in healthy subjects and patients with chronic obstructive pulmonary disease (COPD) [11]. Contraction against an excessive load (isotonic/concentric loading) leads to acute diaphragm injury, inflammation, and weakness [11,12]. Critically ill patients are at especially high risk for load-induced injury as systemic inflammation renders the muscle fiber membrane (sarcolemma) more susceptible to injury [12]. In an experimental sepsis model, applying mechanical ventilation to relieve inspiratory loading significantly attenuates muscle fiber injury and diaphragm weakness [13]. In addition, patients with a thickening fraction value of 15–30% on average during the first 3 days of ventilation (like that of healthy subjects at rest) had stable diaphragm thickness and the shortest duration of ventilation [14].

Conclusion.

In conclusion, the optimal effort level to prevent diaphragm dysfunction is uncertain and may vary according to the patient's clinical condition. Several lines of evidence suggest that maintaining a relatively low effort similar to that of healthy study participants breathing at rest might be the most effective approach. Diaphragm dysfunction might have the impact on the weaning from MV, enabling enough level of respiratory muscles work to maintain spontaneous breathing. Using diaphragm protective MV strategy during weaning process might be helpful strategy to avoid diaphragm myotrauma and train it.

Assistance with the study.

The authors thank all of the pediatric anesthesiologists at the Department of Anesthesiology and Intensive Care, Lviv Regional Children Hospital “OCHMATDYT”, Lviv, Ukraine, for their cooperation in anesthesia and intensive therapy management.

Authors personal contribution.

Concept – Olha Filyk, Yaroslav Pidhirnyi
Data collection and analysis – Olha Filyk
Writing an article – Olha Filyk
Editing and approving the final version of the article – Olha Filyk, Yaroslav Pidhirnyi.

Permission of the Bioethics Commission to conduct research.

The study was approved by the Bioethics Commission of Danylo Halytsky Lviv National Medical University, protocol №1, January 30, 2018. All patients` relatives or their legal representatives signed informed consent to participate in the study.

Conflicts of interest. None.

Financial support and sponsorship. None

REFERENCES

1. Schepens T, Dres M, Heunks L, et al. Diaphragm-protective mechanical ventilation. Current Opinion in Critical Care. 2019;25:77-85.
2. Xue Y, Yang C, Ao Y, et al. A prospective observational study on critically ill children with diaphragmatic dysfunction: clinical outcomes and risk factors. BMC Pediatrics. 2020;20.
3. Filyk O. Diaphragm Dysfunction in Children with Acute Respiratory Failure. Emergency Medicine. 2017;0:73-77.
4. Conti G, Piastra M. Mechanical ventilation for children. Current Opinion in Critical Care. 2016;22:60-66.
5. Pneumonia accounts for 12% of all deaths in children under 5 in European Region.
6. Organization W. Oxygen therapy for children: a manual for health workers.
7. Kneyber M, de Luca D, Calderini E, et al. Recommendations for mechanical ventilation of critically ill children from the Paediatric Mechanical Ventilation Consensus Conference (PEMVECC). Intensive Care Medicine. 2017;43:1764-1780.
8. Grieco D, Menga L, Eleuteri D, et al. Patient self-inflicted lung injury: implications for acute hypoxemic respiratory failure and ARDS patients on non-invasive support. Minerva Anestesiologica. 2019;85.
9. Goligher E, Brochard L, Reid W, et al. Diaphragmatic myotrauma: a mediator of prolonged ventilation and poor patient outcomes in acute respiratory failure. The Lancet Respiratory Medicine. 2019;7:90-98.
10. Schepens T, Dianti J. Diaphragm protection. Current Opinion in Critical Care. 2020;26:35-40.
11. Orozco-Levi M, Lloreta J, Minguella J, et al. Injury of the Human Diaphragm Associated with Exertion and Chronic Obstructive Pulmonary Disease. American Journal of Respiratory and Critical Care Medicine. 2001;164:1734-1739.
12. Jiang T, Reid W, Belcastro A, et al. Load Dependence of Secondary Diaphragm Inflammation and Injury after Acute Inspiratory Loading. American Journal of Respiratory and Critical Care Medicine. 1998;157:230-236.
13. Yoshida T, Roldan R, Beraldo M, et al. Spontaneous Effort During Mechanical Ventilation. Critical Care Medicine. 2016;44:e678-e688.
14. Goligher E, Dres M, Fan E, et al. Mechanical Ventilation–induced Diaphragm Atrophy Strongly Impacts Clinical Outcomes. American Journal of Respiratory and Critical Care Medicine. 2018;197:204-213.

ФУНКЦИЯ ДЫХАТЕЛЬНЫХ МЫШЦ У ДЕТЕЙ 6-18 ЛЕТ С ОСТРОЙ ГИПОКСЕМИЧЕСКОЙ ДИХАЛЬНОЙ НЕДОСТАТОЧНОСТЬЮ: ПРОСПЕКТИВНОЕ ОБСЕРВАЦИОННОЕ КОГОРТНОЕ ИССЛЕДОВАНИЕ

Резюме

Введение. Острая дыхательная недостаточность, вызванная пневмонией, является значимой причиной смерти детей в возрасте 6-18 лет.

Целью исследования было установить, приводит ли дисфункция диафрагмы к неудачному отлучению от ИВЛ.

Материалы и методы. Мы провели проспективное обсервационное когортное исследование, в которое было включено 104 пациента. Все пациенты были разделены на основную и контрольную группы, а также на две возрастных подгруппы. Функцию диафрагмы устанавливали по показателям амплитуды движений ее куполов и фракции истончения.

Первичным конечным результатом исследования была частота успешного отлучения от ИВЛ. Вторичными конечными результатами исследования были изменения показателей функционирования диафрагмы.

Результаты. Показатель фракции истончения для правого купола диафрагмы был достоверно ниже в 1-й подгруппе основной группы на 1-й и 5-й дни и достоверно выше на 14-й день ($p<0,05$), тогда как для левого купола диафрагмы - достоверно выше на 1-й день и достоверно ниже на 7-й день по сравнению с контрольной группой ($p<0,05$). Во 2-й подгруппе основной группы показатель фракции истончения для обоих куполов был достоверно выше на 1 день по сравнению с контрольной группой ($p<0,05$).

Показатель амплитуды движений диафрагмы был достоверно ниже в 1-й подгруппе основной группы на 1-й и 5-й день и достоверно выше на 14-й день по сравнению с контрольной группой ($p<0,05$). Установлено, что частота успешного отлучения от ИВЛ в основной группе была достоверно ниже по сравнению с контрольной группой.

Выводы. Наличие дисфункции диафрагмы может влиять на результаты отлучения от ИВЛ у детей 6-18 лет.

Ключевые слова: физиология дыхания, диафрагма, дыхательная недостаточность, дети.