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## Comparison of two cervical collars on the intracranial pressure measured indirectly based on the thickness of the optic nerve sheath. Preliminary data

### Porównanie dwóch typów kołnierzy szyjnych i ich wpływu na ciśnienie śródczaszkowe mierzone pośrednio w oparciu o grubość otoczki nerwu wzrokowego. Badanie wstępne

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#### Keywords

thickness of the optic nerve sheath, intracranial pressure, ultrasound, cervical collar

#### Słowa kluczowe

grubość otoczki nerwu wzrokowego, ciśnienie śródczaszkowe, ultrasonografia, kołnierz szyjny

#### Summary

**Introduction.** Securing the cervical spine is one of the key elements in dealing with a trauma patient. In the event of an injury, the volume of fluid surrounding the brain increases. Intracranial pressure is an important parameter determining cerebrospinal fluid pressure in the cerebral ventricular system. In the case of massive cerebral edema, cerebral infiltration may occur.

**Aim.** The aim of the study was to assess the effect of using two different types of cervical collars on the increase in intracranial pressure measured indirectly by means of the optic nerve sheath thickness measurement.

**Material and methods.** The study was a prospective, randomized, cross-study and included 20 volunteers. The cervical collar was put on for a period of 10 minutes and the thickness of the optic nerve sheath was evaluated; on the following day, an analogous procedure was performed for the second type of cervical collar. The thickness of the optic nerve was measured based on ultrasound. The study protocol was accepted by the Institutional Review Board of the Polish Society of Disaster Medicine (Approval No. 15/02/2017.IRB).

**Results.** The median optic nerve sheath thickness during the follow-up was 3.6 (IQR: 3.58-3.95) mm, while 10 minutes after immobilizing the cervical spine using a NECKLITE collar was 3.75 (IQR: 3.7-4.2) mm, and in the case of stabilizing the spine using a Patriot collar – 4.6 (IQR: 4.35-4.9) mm.

**Conclusions.** In an experimental study, cervical neck immobilization with the NECKLITE collar was associated with a slight increase in the thickness of the optic nerve sheath, however, the use of a standard Patriot collar showed a significant increase in the thickness of the optic nerve sheath, which may indicate an increase in intracranial pressure.

#### Streszczenie

**Wstęp.** Zabezpieczenie odcinka szyjnego kręgosłupa stanowi jeden z kluczowych elementów postępowania wobec pacjenta urazowego. W przypadku urazu zwiększa się objętość płynów otaczających mózgowie. Ciśnienie śródczaszkowe to ważny parametr określający ciśnienie płynu mózgowo-rdzeniowego w układzie komorowym mózgu. W przypadku masywnego obrzęku mózgu może dojść do wgłobienia mózgowia.

**Cel pracy.** Celem badania była ocena wpływu zastosowania dwóch różnych typów kołnierzy szyjnych na wzrost ciśnienia śródczaszkowego mierzonego pośrednio za pomocą pomiaru grubości otoczki nerwu wzrokowego.

**Materiał i metody.** Przeprowadzone badanie było prospektywnym, randomizowanym, krzyżowym badaniem i objęło 20 ochotników. Kołnierz szyjny był zakładany na czas

### Conflict of interest Konflikt interesów

Lukasz Szarpak works for PerSys as a scientific consultant.

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10 min, po czym oceniano grubość otoczki nerwu wzrokowego, kolejnego dnia wykonywano analogiczną procedurę w odniesieniu do drugiego typu kołnierza szyjnego. Pomiar grubości nerwu wzrokowego wykonano w oparciu o badanie ultrasonograficzne. Protokół badania został zaakceptowany przez Radę Programową Polskiego Towarzystwa Medycyny Katastrof (zgoda: 15.02.2017.IRB).

**Wyniki.** Mediana grubości otoczki nerwu wzrokowego podczas badania kontrolnego wynosiła 3,6 (IQR: 3,58-3,95) mm, podczas gdy po 10-minutowym unieruchomieniu odcinka szyjnego kręgosłupa za pomocą kołnierza NECKLITE wynosiła 3,75 (IQR: 3,7-4,2) mm, zaś w przypadku stabilizacji kręgosłupa za pomocą kołnierza Patriot – 4,6 (IQR: 4,35-4,9) mm.

**Wnioski.** W badaniu eksperymentalnym unieruchomienie odcinka szyjnego za pomocą kołnierza NECKLITE wiązało się z nieznacznym wzrostem grubości otoczki nerwu wzrokowego, jednakże zastosowanie standardowego kołnierza Patriot wykazało się znacznym wzrostem grubości otoczki nerwu wzrokowego, co może świadczyć o wzroście ciśnienia śródczaszkowego.

## INTRODUCTION

Continuous technological progress, including the development of motorization as well as the construction of high-speed routes, increase the number of transport accidents (1, 2). In order to provide rescue services, medical emergency teams and fire departments are available in accordance with Polish legislation. All rescuers are taught to protect and stabilize the trauma patient. The basic rescue procedure in the case of firefighters includes stabilization of the cervical spine, stabilization of fractures as well as the patient himself on the orthopedic board, and the implementation of oxygen therapy. In the case of emergency medical teams, the medical staff has much greater qualifications, however the basic procedure in both cases is analogous (3, 4).

Since 2015, when Bryan Bledsoe published an article on JEMS (5), the routine uses of the cervical collar as a method of stabilizing the cervical segment in trauma patients has been questioned. Currently, more and more studies indicate that the use of a cervical collar does not affect the survival of trauma patients. In addition, the issues of the negative impact of the cervical collar, including discomfort to the patient, impeding the endotracheal intubation of the trauma patient, or pressure – and associated pain – on the mastoid processes, are raised. An additional aspect when using a cervical collar is indicated by Davies et al. (6), there may be an impairment of venous outflow from the head and subsequent increase in intracranial pressure – which is an extremely dangerous symptom in trauma patients (7-9).

## AIM

The aim of the study was to assess the effect of using two different types of cervical collars on the increase in intracranial pressure measured indirectly by means of the optic nerve sheath thickness.

## MATERIAL AND METHODS

The study protocol was accepted by the Institutional Review Board of the Polish Society of Disaster Medicine (Approval No. 15/02/2017.IRB). Prior to the study, all participants were informed about the purpose of the

study and voluntary, written, informed consent was obtained from each participant. Twenty firefighters were included in the study. Inclusion criteria composed of healthy subjects between 18 and 50 years of age who had the carotid sinus ultrasound assessed for pathological changes. Exclusions consisted of head injury in the period of six months preceding the examination, pathological changes in the cervical sinus, or refusal to participate in the study.

The study was designed as a prospective, randomized, crossover study. The study evaluated two types of cervical collars:

1. New NECKLITE moldable neck brace (FLAMOR SRL, San Pietro Mosezzo, Italy) (fig. 1).
2. Standard Patriot cervical extraction collar (Össur Americas, Foothill Ranch, CA, USA).

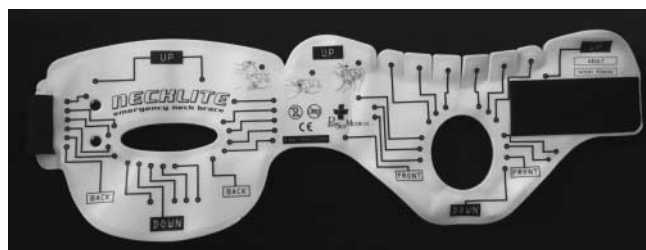


Fig. 1. New NECKLITE moldable neck brace

Prior to the study, a control assessment of the optic nerve sheath thickness was performed using the standard measurement method. Each eye was scanned in both sagittal and transverse planes. Optic nerve sheath diameter accepted worldwide is 3 mm posterior to the retina. For this purpose, an ultrasound device EZONO 5000 (eZono AG, Jena, Germany) was used equipped with a 7.5 MHz linear probe. Both eyes were examined (fig. 2).



Fig. 2. Ultrasonography examination of optic nerve sheath diameter

During the test, the cervical collar was placed in accordance with the manufacturer’s instructions, adjusted to the size of the patient. The patient was placed on a transport stretcher for a period of 10 minutes, followed by a two-sided ONSD measurement. During the next day, the procedure was repeated using the second type of cervical collar. Both the order of use of the neck collars and the order of the participants were random. For this purpose, the Research Randomizer program (randomizer.org) was used. A detailed randomization procedure is shown on figure 3.

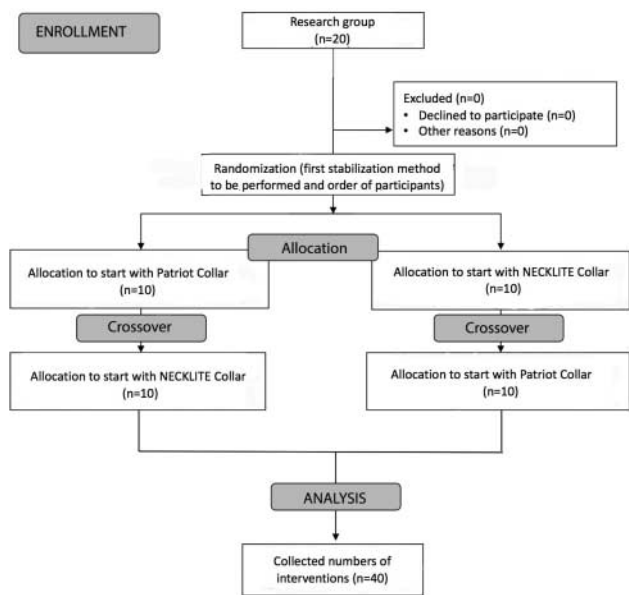


Fig. 3. Randomization flow chart

Descriptive statistics using median and interquartile ranges (IQR) were calculated to summarize the patient characteristics and ONSD measurements. Statistical comparisons of ONSD by time point were conducted using Wilcoxon-Mann-Whitney tests. All analyses were conducted using statistical package Statistica 12.5 EN (StatSoft, Tulsa, OK, USA). A significance level of  $\alpha = 0.05$  was assumed throughout, and any reported p-values are two sided. The study protocol was accepted

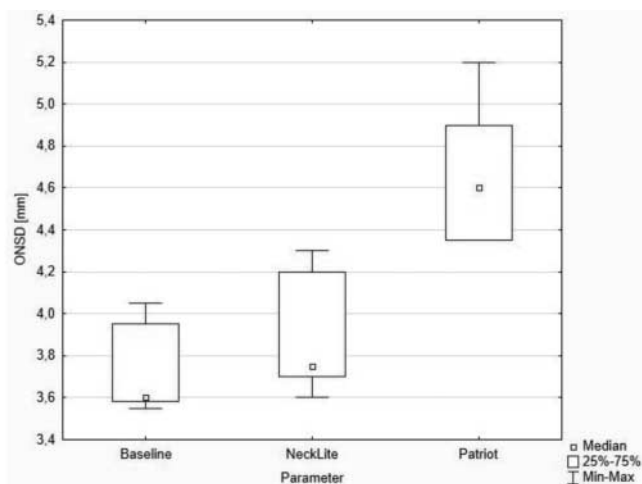


Fig. 4. Results of optic nerve sheath diameter

by the Institutional Review Board of the Polish Society of Disaster Medicine (Approval No. 15/02/2017.IRB).

## RESULTS

The survey involved 20 firefighters, with a median age of 34 years (IQR: 29-37). All subjects were men.

The results of the optic nerve sheath diameter test are shown on figure 4. Median optic nerve sheath diameter during baseline was 3.6 mm (IQR: 3.58-3.95). When using the NECKLITE cervical collar, an increase in ONSD to 3.75 mm was observed (IQR: 3.7-4.2), meanwhile the PATRIOT collar showed an ONSD of 4.6 mm (IQR: 4.35-4.9). Statistical analysis showed statistically significant differences in optic nerve sheath diameter between Baseline and Patriot Collar ( $p = 0.01$ ), and between Baseline and NECKLITE ( $p < 0.001$ ), as well as between individual collars of NECKLITE and Patriot ( $p < 0.01$ ; tab. 1).

Tab. 1. Optic nerve sheath diameter

Stabilization method	Optic Nerve Sheath Diameter (mm)	p-value
No Collar – Baseline	3.6 (IQR: 3.58-3.95)	Baseline vs. NECKLITE – $p < 0.001$
NECKLITE	3.75 (IQR: 3.7-4.2)	
Patriot Collar	4.6 (IQR: 4.35-4.9)	Baseline vs. Patriot – $p = 0.01$ NECKLITE vs. Patriot – $p < 0.01$

## DISCUSSION

Securing the cervical spine in case of suspected damage to the spine is one of the basic elements of the rescue procedure, aimed at reducing further damage to the spine and spinal cord (10, 11).

As seen in previous studies published by the team of Ladny et al. (12) in the pages of the Disaster and Emergency Medicine Journal, the standard application is associated with a significant limitation of the degree of mouth opening, and thus a problem in the patient’s intubation. This problem is also addressed by other researchers who have demonstrated a significant reduction in the effectiveness of endotracheal intubation based on direct laryngoscopy (13, 14). However, according to studies by Ladny et al. (12) thanks to a special construction, the innovative NECKLITE cervical collar allows full adjustment of individual parts to the anatomical conditions of the patient, allowing to bend the occipital part or the area supporting the mandible during intubation.

Ferguson et al. suggested that rigid cervical collars may cause compression and distortion of neck veins (15). The impairment of the venous outflow of blood from the head as a result of the use of cervical collar may result in an increase in intracranial pressure and subsequent intussusception are also indicated by other authors (9, 16-18). In our own study, a significant increase in the thickness of the optic nerve sheath was observed only when using the standard Patriot neck collar, in the case of the NECKLITE collar only a slight

increase in the thickness of ONSD was observed, which was not statistically significant.

The study has limitations. The first limitation is the use of only two methods of immobilization of the cervical spine, however, further studies are underway to analyze the cervical collars available on the medical market. The second limitation is the performance of a study based on healthy volunteers, however, cross-randomized studies in the setting of emergency medicine would be impossible due to the potential additional injuries to patients. The undoubted advantage of the study is its randomized cross-study nature.

## CONCLUSIONS

In the experimental study conducted, the use of a standard cervical collar caused a significant increase in optic nerve thickness, which is a manifestation of an increase in intracranial pressure. The use of the innovative NECKLITE cervical collar was associated with a much smaller increase in the thickness of the optic nerve sheath. Further research is necessary to confirm the results obtained.

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