STRANGULATED HERNIA: DOES SHORTER TIME TO THE OPERATING ROOM REDUCE THE OCCURENCE OF INTESTINAL NECROSIS?

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Strangulated hernia: does shorter time to the operating room reduce the occurence of intestinal necrosis?
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Surgical operations of abdominal wall hernias are one of the most common types of surgical procedures in general surgery. Being able to assess severity of a strangulated hernia (SH) in the acute setting would help the physicians and staff to easily triage and prioritize patients (pts.) in greater need of emergent care. By handling the pts. correctly and tending to their needs, complications such as intestinal necrosis (IN) and resection can be avoided, and postsurgical complications could be minimized. The morbidity following a surgical procedure does not only bring with it a social burden but also a financial burden for the pts. and the caregiver. Optimizing the care for SH will benefit all involved. There have been many case studies on hernias but so far, few authors have tried to tackle how to better manage pts. with strangulated hernia by retrospectively analyzing for time strangulation and blood parameters that could prove useful in assessing severity of irreversible ischemic damage of the incarcerated bowel.
Purpose: The aim of this retrospective study was to collect and analyze data from Kaunas University Hospital (KUH), that could prove useful in correctly assessing severity of the SH to better prioritize pts. care and thereby decreasing risk of postoperative morbidity and mortality.
Objectives: 1. To divide duration of strangulated hernia in different periods and analyse the time which could influence the occurrence of IN. 2. To determine a cut-off value linking duration of symptoms to when IN is more likely. 3. To identify the criteria and biomarkers this could predict the risk of IN occurrence for patients with SH.
Methods: Patient data was collected from the Department of Surgery of Hospital of Lithuanian University of Health Sciences (LUHS) between years 2015 – 2020. The sample size of this study was 151 pts.: 66 males (43.7%) and 85 females (56.3%)
Results and conclusions: We discovered that duration of symptoms is the most important variable having the highest influence on the risk of development of intestinal necrosis. Duration of > 12 hour in combination with age > 70 and increased inflammatory biomarkers, especially LDH acts as main predictive factor for development of necrosis and need for bowel resection. Once patient presented at the emergency room there seemed to be no delay that influenced the risk of necrosis.
Keywords: *strangulated hernia, intestinal necrosis, bowel resection, inflammatory biomarkers, duration of symptoms.*

Қысылған жарық: операция бөлмесінде болу уақытының қысқаруы ішек некрозының пайда болу ықтималдығын төмендетеді ме?
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Өзектілігі. Іш қабырғасының жарығына байланысты хирургиялық операциялар жалпы хирургиядағы операциялардың ең көп таралған түрлерінің бірі болып табылады. Шұғыл жағдайда қысылған жарықтың (ҚЖ) ауырлығын бағалау мүмкіндігі дәрігерлер мен қызметкерлерге шұғыл көмекті көп қажет ететін пациенттердің басымдығын реттеуге және анықтауға көмектеседі. ҚЖ бар пациенттерді уақытылы диагностикалау және адекватты көмек көрсету ішек

некрозы (ІН) мен резекциясы сынды асқынуларды болдырмауға, сондай-ақ операциядан кейінгі асқынуларды барынша азайтуға көмектеседі. Операциядан кейінгі сырқаттанушылық әлеуметтік ауыртпалықпен қоса, пациенттер мен олардың қамқоршысы үшін қаржылық проблемаларды тудырады. ҚЖ емдеуді оңтайландыру барлық қатысушыларға пайдалы болар еді. Жарық туралы көптеген зерттеулер жүргізілді, алайда осы уақытқа дейін ҚЖ бар пациенттерді қалай жақсы емдеу керектігін шешуге тырысқан авторлардың саны аз. Страгуляция уақытын және қан параметрлерін ретроспективті талдау арқылы қысылған ішектің қайтымсыз ишемиялық зақымдануының ауырлығын бағалау кезінде пайдалы болуы мүмкін.

Мақсаты. Бұл ретроспективті зерттеудің мақсаты ҚЖ ауырлығын дұрыс бағалау және пациенттердің басымдықтарын жақсы анықтау үшін пайдалы болатын Каунас университетінің ауруханасынан алынған деректерді жинау мен талдау, осылайша операциядан кейінгі ауруды және өлім-жітім қаупін азайту болып табылады.

Міндеттері. 1. ҚЖ ұзақтығын түрлі кезеңдерге бөлу және ІН пайда болуына әсер етуі мүмкін уақытты талдау. 2. ІН ықтималдығы жоғары болған кезде симптомдардың ұзақтығын байланыстыратын шекті мәндерін анықтау. 3. ҚЖ бар пациенттерде ІН пайда болу қаупін болжауға мүмкіндік беретін өлшемшарттар мен биомаркерлерді анықтау.

Әдісі.: Пациенттер туралы деректер 2015-2020 жылдар аралығында Литва денсаулық ғылымы университетінің Каунас клиникасындағы хирургия бөлімінен алынды. Зерттеуге 151 пациент қатыстырылды: ерлер 66 (43,7%) және әйелдер 85 (56,3%).

Нәтижелері мен қорытындылары. Біз симптомдардың ұзақтығы ішек некрозының даму қаупіне ең көп әсер ететін маңызды айнымалы болып табылатынын анықтадық. 70 жас үйлесімінде ұзақтығы 12 сағат және қабыну биомаркерлері, әсіресе лактадегидрогеназдың (ЛДГ) жоғарылауы некроздың дамуының негізгі болжамды факторы мен ішек резекциясы қажеттілігі болып табылады. Пациент жедел жәрдем бөлімшесіне жеткізілгеннен кейін некроз қаупіне әсер ететін ешбір кедергі анықталмады.

Негізгі сөздер: қысылған жарық, ішек некрозы, ішек некрозы, қабыну маркерлері, симптомдар ұзақтығы

Ущемленная грыжа: снижает ли сокращение времени пребывания в операционной вероятность возникновения некроза кишечника?
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Введение. Хирургические операции по поводу грыж брюшной стенки являются одними из наиболее распространенных видов оперативных вмешательств в общей хирургии. Возможность оценить тяжесть ущемленной грыжи (УГ) в неотложной ситуации поможет врачам и персоналу расставить и определить приоритеты пациентов, которые больше нуждаются в неотложной помощи. Своевременная диагностика и адекватная помощь пациентов с УГ поможет избежать таких осложнений, как некроз кишечника (НК) и резекцию, а также свести к минимуму послеоперационные осложнения. Заболеваемость после хирургического вмешательства влечет за собой не только социальную нагрузку, но и финансовые проблемы для пациентов и их опекунов. Оптимизация лечения УГ пошла бы на пользу всем участникам. Было проведено много тематических исследований о грыжах, но до сих пор лишь немногие авторы пытались решить, как лучше лечить пациентов с УГ путем ретроспективного анализа времени странгуляции и параметров крови, которые могут оказаться полезными при оценке тяжести необратимого ишемического повреждения ущемленной кишки.

Цель: Целью этого ретроспективного исследования было собрать и проанализировать данные из Каунасской университетской больницы, которые могут оказаться полезными для правильной оценки тяжести УГ для лучшего определения приоритетов пациентов, ухода и тем самым снизить риск послеоперационной заболеваемости и смертности.

Задачи: 1. Разделить длительность УГ на разные периоды и проанализировать время, которое могло повлиять на возникновение НК. 2. Определить пороговое значение, связывающее продолжительность симптомов с тем, когда НК более вероятен. 3. Определить критерии и биомаркеры, позволяющие прогнозировать риск возникновения НК у пациентов с УГ.

Методы. Данные о пациентах были собраны в отделении хирургии в Каунасской

клинике Литовского университета наук о здоровье в период с 2015 по 2020 год. В исследование включен 151 пациент: 66 мужчин (43,7%) и 85 женщин (56,3%). Результаты и выводы. Мы обнаружили, что продолжительность симптомов является наиболее важной переменной, оказывающей наибольшее влияние на риск развития некроза кишечника. Продолжительность > 12 часов в сочетании с возрастом > 70 лет и повышением воспалительных биомаркеров, особенно лактадегидрогеназы (ЛДГ), выступает в качестве основного прогностического фактора развития некроза и необходимости резекции кишечника. Как только пациент был доставлен в отделение неотложной помощи, не было никакой задержки, которая влияла бы на риск некроза.

Ключевые слова: ущемленная грыжа, некроз кишечника, резекция кишечника, биомаркеры воспаления, длительность симптомов.

List of abbreviations

AWH	Abdominal wall hernia
SH	Strangulated hernia
Pts	Patients
KUH	Kaunas University Hospital
IN	Intestinal Necrosis
LUHS	Lithuania University of Health Sciences
BR	Bowel resection
H	Hours
ASA	American Society of Anesthesiology
WBC	White blood cells
NLR	Neutrophil to Lymphocyte Ratio
CRP	C-reactive Protein
Symptoms-ER	Time from the onset of symptoms to the arrival at the emergency room
ER	Emergency Room
ER-OR	Time from confirmed diagnosis in emergency room to operating room
OR	Operation Room
Symptoms-OR	Total time from onset of symptoms to start of the surgery
LDH	Lactate dehydrogenase
BE	Base excess
IBM	International Business Machines Corporation
SPSS	Statistical Package for the Social Sciences
ROC	Receiver Operating Characteristic curve
FN	Fat necrosis
Y	Years
T-ER	Time spent in emergency room
AUC	Area under the curve

Introduction

AWH repairs are the single most common surgery performed in the general surgery setting. In USA alone, around 1 million hernias are repaired annually and in UK there are over 100 000 repairs annually [1, 2].

Abdominal wall hernias (AWH) are best dealt with in an elective setting where the need for bowel resection (BR) is lower than in an emergency setting. According to Andrews et.al. the need for BR for SH is 27% and the mortality rate is 21% if the diagnosis is delayed longer than 48 hours (h); whereas rates were 7% and 1.4% respectively when diagnosis is obtained within the first 24 h [3]. This is of great importance for the quality of life of the patient and could also aid healthcare workers to prioritize their work accordingly.

Conditions leading to herniations of abdominal contents through the abdominal wall are vast and typically divided into two categories: congenital and acquired. Congenital abnormalities can arise during the 6th week of gestation during which the abdominal content is temporarily protruded through the umbilical cord due to the increasing size of abdominal content and the inability of the abdominal cavity to host the growing viscera. A defect arising due to this process invariably leads to omphalocele or gastroschisis. Umbilical hernia is present in 10% of all new-borns but usually spontaneously close at the age of five. Another congenital defect that may relate to herniations is congenital rectus abdominis diastasis where rectus muscles insert to the ribs laterally to the midline [4].

Acquired conditions increasing the risk of herniations include rectus abdominis diastasis due to pregnancy, obesity and increasing age; rectus sheath hematoma due to blunt force trauma, coughing, sneezing, vigorous physical activity, or spontaneous hematomas due to anticoagulation therapy; incisional hernia due to failed healing of surgical incisions; advanced liver disease leading to umbilical hernia. Inguinal hernias are of multifactorial aetiology with physical exertions and increased intrabdominal pressure seems to play a key factor but also some connective tissue disorder, such as osteogenesis imperfecta, alpha1-antitrypsin deficiency and Marfan syndrome, seems to play a major role in development of inguinal hernia [4].

In trials from UK by Dwyer et. al and North America by Fittzgibbons et. al, the benefit of watchful waiting versus minimal invasive surgical repair of asymptomatic inguinal hernias were compared [5, 6]. As a result, watchful waiting was suggested by Simons et. al and the European hernia society as the first choice of treatment for non-incarcerated inguinal hernia [7]. However, Hwang et al. believe that the follow up provided by these trials might not represent the "real world practice" due to limitations of follow up in the "real life" setting [6]. This becomes very important when mortality rate following elective repair is less than 1%, while in emergency repair it is over 5% [8].

Xie et al. claim that once herniations become incarcerated they are no longer handled with elective approach. Emergency surgical repair is the only treatment to prevent strangulation, from which it can quickly

become ischemic, increasing the risk of needing a BR. Visceral herniation is best handled in the non-acute setting as an elective surgery since it carries a lower risk of morbidity and mortality [9]. Andrews et. al suggested that for incarcerated hernias the need of BR is 27% and the mortality rate is 21% if diagnosis is delayed longer than 48 h; whereas rates were 7% and 1.4% respectively when diagnosis was obtained within the first 24 h [3].

Inflammatory markers have shown to be a good predictor of severity of disease. Galizia et.al., Li et. al., Kacan et. al., Nakayama et. al. noted that especially neutrophil-to-lymphocyte ratio (NLR) can be a good predictor of the difficulty of an inflammatory disease [10-12]. It also seems to reflect the body's response to cancer cells and might be capable to predict the prognosis of pts. with certain types of cancer such as colon cancer, non-small cell lung and gastric cancer [10-13]. Forget et. al. concluded that in an adult non-geriatric population in good health the NLR values are between 0.78 – 3.53 [14]. Zhou et al. reported that NLR > 6.5 is a good indicator of strangulation in pts. with inguinal hernia [15]. In a study Xie et.al. concluded that pts. with groin hernia with presentation of bowel obstruction and a pre-operative NLR above 11.5 had higher risk of BR [9]. Other researchers such as Kahramanca et.al. observed that pre-operative WBC count and fibrinogen levels were highest in pts. with incarcerated hernia that underwent emergency surgery and lowest in pts. that underwent elective hernia repair. Increased level of fibrinogen was also related to increased risk of BR, increased hospital stays, need for intensive care and increased cost. High level of fibrinogen was also found in deceased pts. On the contrary pts. undergoing elective surgery had higher levels of Mean Platelet Volume and Platelet Distribution Width [16]. In a study conducted by Kohag et al. they divided pts. into two groups, depending on whether they underwent open or laparoscopic surgery. Pts. who were assessed as having a severe disease underwent open surgery and the rest underwent laparoscopic surgery. Factors determining severe disease were severe condition and severe intestinal dilation. In both groups preoperative clinical variables were assessed and there was a clear correlation between severity of disease and increased C-reactive Protein (CRP) and WBC counts [17].

Duration of symptoms seems to be correlated to disease severity however there are not enough data and researchers seems to be divided in setting a cut off value for when to expect necrosis of hernia content. Kurt et. al. suggested that > 6 h of symptoms could be a good predictor of necrosis in contrast Xie et. al. concluded that > 26 h was an independent risk factor for necrosis [9,18]. Yet another study done by Ge et. al. concluded that longer duration of symptoms may indicate need for BR due to necrosis, but their finding was not statistically significant with 33.9 ±52.0h (p=0.062) being the mean duration for resection of necrotic hernia content [19].

In their study Abi Haidar et. al. compared the outcome of acute versus elective groin hernia repairs where recurrent hernias represented 30.9% of the acute repairs. Acute surgeries were also related to increased risk of intraoperative organ resection [20]. Köcklinger et. al. wrote that the demand for material replacing and enhancing the inherent tissue when impaired is increasing in all fields of surgery. Types of materials are used when surgically correcting a hernia: biological and synthetic meshes [21]. Jenkins et. al. stated that there is clear evidence that hernia repair with mesh is more effective than sutured techniques in preventing recurrence- [22]. Biological meshes provided an alternative to the older synthetic mesh and is historically preferred in settings when postsurgical infections are to be expected. In theory, since the biological mesh incorporated into the native tissue, it acquires the capability to resist infections. Even though there is no clinical data confirming that biological mesh is superior to the synthetic mesh many surgeons have adopted the use of biological mesh because the outcome is perceived to be better. The "BioMesh Study Group" comprising of surgeons with special interest in surgical meshes analyzed 114 reviews on the available evidence on use of biological and synthetic meshes. In conclusion:

Under contaminated conditions the biological mesh showed no superiority over synthetic mesh.

In situations of bridging, biological and biosynthetic mesh should not be used.

There is no advantage of biological or biosynthetic mesh in inguinal hernia repair.

No evidence supporting prevention of incisional or parastomal hernia with biological or biosynthetic mesh.

Biological and biosynthetic mesh not superior alternative to synthetic mesh in complex AWH repairs [21].

In literature, the outcome of a hernia repair depends on parameters such as age, sex, and American Society of Anesthesiology (ASA) score. Some researchers have suggested that assessing white blood cell (WBC) count and fibrinogen could be an approach of predicting the condition of incarcerated content. In this study we have collected and analyzed retrospective data from all 151 patients who underwent surgery for SH in the Department of Surgery of Hospital of LUHS between years 2015 – 2020 to find any parameters that could aid physicians in better predicting whether a hernia is in greater risk of intestinal necrosis. By finding specific parameters that correlate with the severity of disease this could help surgeons to better assess whether a patient with a strangulated hernia is in acute need of surgery and to predict the outcome.

Purpose

The purpose of this retrospective study was to collect and analyze data from Kaunas University Hospital (KUH), that could prove useful in correctly assessing severity of the SH to better prioritize pts. care and thereby decreasing risk of postoperative morbidity and mortality.

Objectives

To divide duration of strangulated hernia in different periods and analyse the time which could influence the occurrence of IN.

To determine a cut-off value for duration of symptoms when IN is more likely.

To identify the criterions and biomarkers this could predict the risk of IN occurrence for pts. with SH.

Methods

This was a retrospective study of pts. who underwent surgery for strangulated hernia in the Department of Surgery of Hospital of LUHS between years 2015-2020.

Pts. charts were reviewed, sample characteristics such as age, gender and hernia types were noted. Time from the onset of symptoms (moment of strangulation) to the arrival at the emergency room (Symptoms-ER), from the confirmed diagnosis in emergency room to operating room (ER-OR) as well as total time from onset of symptoms to start of the surgery (Symptoms-OR) were calculated. Intraoperative findings were reviewed for each pts. The samples were divided into two groups based on occurrence of IN.

Following biomarkers WBC, CRP, neutrophils (%), lymphocytes, NLR, Lactate dehydrogenase (LDH), blood pH and base excess (BE) were analyzed to identify markers that could predict intestinal necrosis.

The statistical analysis was carried out using IBM SPSS Statistics® 20.0. Student's t-test were used to compare parametric, $\chi2$ and Mann-Whitney U test – nonparametric variables. Receiver operating characteristic curve (ROC) curves were used to determine the cut-off point for time of symptoms. The logistic regression analysis was used to determine independed risk factors of intestinal necrosis. Quantitative data was expressed as mean and standard deviation. P<0.05 was considered statistically significant.

Results

A total of 151 pts. (66 males and 85 females) underwent surgery for SH. The mean age was 65.6 ±17.9 y. The females in this study were significantly older compared to males (69.2 ±16.3 y vs. 60.9 ±18.9 y; p=0.035). Inguinal and postoperative hernias were the most common type of SH (Tab. 1).

Table 1. *Type of hernia*

Inguinal (n/%)	54	35.8
Femoral (n/%)	30	19.9
Umbilical (n/%)	28	18.6
Postoperative (n/%)	36	23.8
Parastomal (n/%)	3	1.9

SH with necrosis was identified for 41 (27.2%) pts. of 151 during surgery. IN was found for 35 (85.4%) pts. and fat necrosis (FN) (necrosis of strangulated omentum or preperitoneal fat) - for 6 (14.6%) pts. Generally, pts. with necrosis, whether fat or intestinal, were older compared to pts. for whom necrosis did not occur: (73.7±18.5 vs. 64.7±17.7 years (y) (FN) and 74.6±15.8 vs. 62.8±17.6y (IN)). But significant difference in age was only found for pts. with IN (p=0.001).

Symptoms-ER and Symptoms-OR were significantly longer for pts. with intestinal necrosis, while there was no difference between groups when comparing ER-OR. Interestingly enough, we also found that time spent in the ER (T-ER) itself was significantly longer in the necrosis group (Tab. 2).

Table 2. Comparison of duration (time in hours) of strangulated hernia in different periods between patients without and with intestinal necrosis

	Without necrosis N=140	Intestinal necrosis N=35	p
Symptoms-ER	13.9 ± 18.5	48.6 ± 39.7	<0.001
ER-OR	2.8± 3.8	3.7 ± 3.6	0.854
Symptoms-OR	16.8 ± 20.8	52 ± 40.4	<0.001
T-ER	1.7 ± 2.1	2.5 ± 3.2	0.024

Symptoms-ER, ER-OR, Symptoms-OR were longer for pts. with FN but without significant differences. T-ER itself was significantly longer in the FN group (Tab. 3).

As can be seen Symptoms-ER and T-ER are the two most important variables having the highest influence on the risk of development of IN.

Table 3. Comparison of duration (time in hours) of strangulated hernia in different periods between patients without and with fat necrosis

	Without necrosis N=140	Fat necrosis N=6	p
Symptoms-ER	21.1 ± 29.2	31.1 ± 26.9	0.926
ER-OR	2.9± 3.6	4 ± 4.5	0.396
Symptoms-OR	24 ± 30.6	34.5 ± 28.8	0.795
T-ER	1.8 ± 2.2	2.5 ± 3.9	0.027
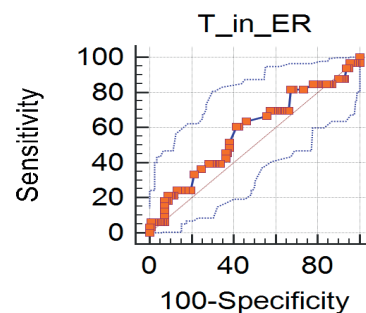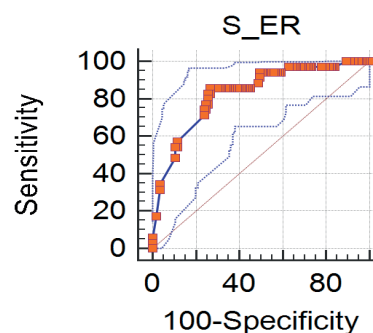
ROC curve characteristics (Symptoms-ER)

AUC	p	95% CI	Cut-off point
0.829	<0.001	0.759-0.886	> 12

ROC curve characteristics(T-ER)

AUC	p	95% CI	Cut-off point
0.578	0.186	0.494-0.659	> 1.15

Fig. 1. ROC curve analysis of time of Symptoms-ER and Time spent in ER

Using the Youden index we determined that the best cut-off point of Symptoms-ER to be >12 h. We did not find that T-ER was important for IN. The critical value (cut-off point) was > 1.15 h, but there was not significant important value.

Our study also revealed that pts. with IN had significantly higher biomarkers except for lymphocytes (Tab. 4).

ROC curve analysis showed that LDH was the most predictive biomarker (AUC > 0.8) for IN (Tab. 5).

Table 4. Comparison of biomarkers between different patient groups

Biomarkers	Without necrosis N=140	Intestinal necrosis N=35	p
WBC	11.69 ± 4.3	14.32 ± 5.5	0.001
Neutrophils (%)	75.63± 13.22	83.89 ± 5.88	0.001
Lymphocytes	1.15 ± 0.76	1.19 ± 0.49	0.827
NLR	6.86 ± 5.32	8.85 ± 5.98	0.027
CRP	58.3± 63.4	165.5 ± 125.3	<0.001
LDH	2.3 ± 1.2	4.7 ± 2.4	<0.001
pH	7.40 ± 0.44	7.30 ± 0.11	0.002
BE	-3.87 ± -2.94	-6.76 ± -2.89	0.004

Table 5. ROC curve characteristics of biomarkers

Biomarkers	AUC	p	95% CI	Cut-off point
WBC	0.632	0.043	0.542-0.716	> 17
Neutrophils (%)	0.754	<0.001	0.665-0.830	> 81
NLR	0.671	0.015	0.552-0.776	> 6.78
CRP	0.734	<0.001	0.646-0.810	> 133
LDH	*0.827*	*<0.001*	*0.681-0.925*	*> 3*
pH	0.779	<0.001	0.623-0.894	< 7.34
BE	0.763	<0.001	0.605-0.882	> -5

The logistic regression analysis assessed that independent risk factors of IN were age > 70 y, duration of symptoms > 12 h, increased WBC, neutrophils, NLR CRP, LDH, pH and BE according to their ROC curve analysis and cut-off values (Tab. 6)

The results suggest IN for pts. with SH if duration of symptoms are > 12 h, age > 70 years or increased WBC, neutrophils, NLR CRP, LDH, pH and BE according standardized reference intervals.

There were 12 cases (7.9%) of deaths in our study. Two pts. (1.4%) died in the group without IN necrosis and 10 patients (28.6%) in the group with IN. The reasons of death in first group were associated with pts. conditions such as old age and severe comorbidities. The reasons of death in the second group were severe comorbidities and postoperative complications such as intraabdominal abscesses and anastomosis leakage with secondary peritonitis.

Discussion and recommendation

There is undoubtedly a correlation between duration of symptoms and increased risk of BR in patients with SH. Kurt et. al. suggested a 6 h cut off point from when symptoms first appeared, and the pts. presented to hospital to be significant for BR [18]. Another research done by Xie et. al. found 26h of incarceration to be of great predictive value for BR [9]. In our study we found that > 12 h anamnesis of symptoms before presenting to the ER could serve as a prognostic tool for predicting IN and need for organ resection. Even though most research correlates the increased duration of symptoms and a negative outcome, further research is needed to reach a consensus on what duration lead to ischemia and necrosis. This would not only help the physician to better expect what treatment is needed but also to better and more accurately explain the condition of the pts. to him-/herself and concerned family and friends.

Table 6. The independent risk factors of intestinal necrosis

Risk factors	OR	95% CI	p
Age > 70 y.	4.56	1.957-10.611	<0.001
Symptoms-ER >12 h.	16.6	5.898-46.719	<0.001
WBC > 17	12.7	4.596-35.12	<0.001
Neutrophils >81%	6.81	2.602-17.845	<0.001
CRP > 133	17.56	6.043-50.994	<0.001
NLR > 6,78	8.01	2.367-27.147	<0.001
LDH >3	15.2	3.222-71.382	0.006
pH < 7.34	7.87	1.688-36.72	0.02
BE < -5	16.8	3.4-83	0.003

As could be predicted the Symptoms-ER and Symptoms-OR were the two variables having the highest

influence on the development of necrosis. Once the patient seeks the ER the further handling depends on the competence of the physician which according to our data seems not to have played a major role in developing necrosis. The data together with the results, Symptoms-ER 48.6 ± 39.7, brings with it a question: why aren't patients seeking medical care in an earlier stage of disease? As with anything else this might be of a multivariate reason. Are people in region of Kaunas seeking medical assistance later than people in other parts of Lithuania or any other part of the world? Is there a lack of education that might contribute to lower understanding of one's symptoms? Is Hospital of LUHS too remote for patients to seek medical care or don't they have a well-established primary healthcare that can understand and refer patients to the right clinic. This topic is of great importance from a public health perspective and should be investigated further.

Blood samples and biochemical evaluation are of routine procedure in the clinical setting. Studies have been done to find a single or a set of biochemical parameters that could accurately diagnose disease severity. Even though our data was not representative of the whole sample size due to lack of journal documents we chose to analyse them (CRP n=67; WBC n=72; Neutrophils n=59; NLR n=59; LDH n=14; Blood pH n=12; BE n=12). The reason why data is missing is mostly dependent on that the old patient data was collected from paper journals from the hospital archive. Paper journals are highly operator dependent, and documents could go missing due to many reasons including neglect of properly attaching paper documents to journals, transport of data and whilst handling the journals in the archive. One that has repeatedly been suggested for assessing disease severity is NLR. In their study Forget et. al. concluded that in an adult non-geriatric population in good health the NLR values are between 0.78–3.53 [14]. Galiza et.al., Li et. al., Kacan et. al., Nakayama et. al. all observed rise in NLR during different types of cancer [10,12,13]. In their study Xie et.al. and Zhou et al. both observed the NLR which showed a significant relationship between increasing NLR, > 6.5 and > 11.5 respectively, and the need for BR [9,15]. In our study the mean NLR value for the group with IN was 8.85 ± 5.98 with an area under the curve (AUC) of 0.671 and p=0.05. Statistically significant but not sensitive.

In our study we found LDH to be the most reliable parameter with an AUC of 0.827 and p < 0.001. Statistically significant and sensitive. In the group with IN we had a mean LDH of 4.7 ± 2.4 mmol/l. Other parameters such as WBC, Neutrophils (%), CRP, pH and BE were assessed. In our sample size all the parameters were generally increased compared to standard reference intervals.

Conclusion

Shorter time to OR from ER for pts. with strangulated hernia does not reduce the occurrence of IN.

Time from onset of symptoms to arrival at the ER is the most important period to predict the risk of IN and time of cut-off point is > 12 h.

The main risk factor of IN in patients with SH is duration of Symptoms-ER. This period together with pts. age >70 y and increased biomarkers such as WBC, neutrophils, NLR CRP, LDH, pH and BE (according to standard reference intervals) could predict IN for pts. with SH.

With the results obtained in our study we recommend the following guidelines for management of SH:

If duration of SH is > 12 h and pts. age is > 70 y with high biomarkers (according to standard cut-off values) it should awaken suspicion of IN with need for urgent surgical intervention.

If duration of SH is < 12 h and biomarkers are less then cut-off values we may prepare pts. for delay urgent surgery (if necessary), preferably laparoscopic approach, especially for strangulated femoral and inguinal hernias. Laparoscopic repair of SH could reduce postoperative pain, wound complications, and duration of postoperative hospitalization.

Suggestions for future studies:

Duration of Symptoms-ER acts as the main risk factor for developing necrosis. In our study mean duration for patients seeking ER was 48.6 ± 39.7. This is very important in a public health perspective and if patient sought medical care earlier in disease stage, we could expect decreasing frequency of necrosis and BR. Future studies should focus on this topic and how to best educate society in appreciating and understanding symptoms of disease.

Previous studies have suggested that NLR is of great importance for assessing severity of disease and it has also been used in the clinical setting for pts. with hernias. In our study we saw that an NLR of > 6.78 could suggest IN in all types of hernias. Other studies have indicated an NLR of > 6.5 as indicative of strangulation and > 11.5 as high risk for BR in patients presenting with inguinal hernias [9,15]. Further studies are necessary to find a cut off value that could be used in the clinical setting to better diagnose the patient with hernia strangulation and necrosis. Since previous studies have only focused on inguinal hernias and their results are different from ours one might believe that different hernias express different levels of biomarkers.

In our study a total of 10 pts. (28.6%) died in the group with intestinal necrosis due to severe comorbidities and postsurgical complications such as intraabdominal abscesses and anastomosis leakage with secondary peritonitis. Another interesting topic would be to investigate whether these are the most common postsurgical complications related to hernia repair leading to death. And if so, maybe an international guideline on how to best prevent and treat these complications should be established.

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