Aus der Chirurgischen Klinik der Medizinischen Fakultät Mannheim
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SURGICAL TREATMENT OF OGILVIE'S SYNDROME

A monocentric outcome analysis

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LIST OF ABBREVIATIONS

ANS	Autonomous Nervous System
ASA-Score	American Society of Anesthesiologists' physical status classification
ATP	Adenosine Triphosphate
CT	Computer Tomography
ECMO	Extracorporeal Membranic Oxygenation
ENS	Enteric Nervous System
GI tract	Gastrointestinal tract
ICD 10	International statistical Classification of Disease, 10th version
ICG	Indocyanine Green fluorescence
ICU	Intensive Care Unit
NOMI	Non-Occlusive Mesenteric Ischemia
OR	Operating Room
PEC	Percutaneous Endoscopic Colostomy
PEG	Percutaneous Endoscopic Gastrostomy
SAS	Statistical Analysis System

1 INTRODUCTION

1.1 Definition and a brief history of Ogilvie's syndrome

Acute colonic pseudo-obstruction, also known as "Ogilvie's syndrome", refers to a gross dilatation of the colon without any evidence of an occlusive gut lesion. It was first described in 1948 by Sir William Heneage Ogilvie (Ogilvie 1948) and its pathophysiology is still mostly unknown. The colon segment most often affected is the cecum, but the dilatation can sometimes expand up to the rectosigmoid junction.

In his original article, Sir Ogilvie reported of two cases of patients with intraabdominal malignancy and with symptoms clearly suggestive of bowel obstruction, whose colon was found to be normal upon surgical inspection. There were no signs of colonic infiltration upon extensive histological analysis. He then argued, that this might be a result of their tumor infiltrating their splanchnic nerves and thus effectively ablating the sympathetic innervation, allowing for the parasympathetic innervation to act unopposed.

Various other authors have investigated the syndrome in the following years. Bardsley in 1974 (Bardsley et al. 1974) further described twelve cases of the syndrome and observed that the site of pseudo-obstruction was located in points were the colon "changes" from being fixed to being mobile. In other words, the points where the colon emerges from its retroperitoneal position, such as the hepatic and splenic flexure, or the rectosigmoid junction. He also described, that the syndrome was usually associated with a variety of co-existing pathologies and, that these patients were commonly described as being "ill".

In a series of 400 cases published in 1985, Vanek and Al-Salti categorized the colonic pseudo-obstruction in acute and chronic. The first one involving an acute massive colonic distension, usually in the cecum and/or right hemicolon, whereas the second describing a chronic hypomotility and distention of the colon, without presenting a life-threatening condition (Vanek et al. 1985).

Ponec et al. in 1999 also described a pharmacological approach to this syndrome, based on the theory that an autonomous imbalance plays a major role in the pathogenesis of the syndrome. They proceeded to conduct a double-blind, placebo-controlled study, testing the effects of neostigmine as a potential causal therapy (Ponec et al. 1999).

In a 2009 review of the literature, the definition was solidified as being a clinically and radiologically acute segmental colonic dilation with absence of mechanical causes (De Giorgio and Knowles 2009). At the point, it had become clear that the syndrome usually affected elderly patients, who often had a wide range of co-morbidities and it was argued that early recognition was hard but essential for a good clinical outcome. A cecal diameter of >12 cm was described as “at risk”, although it was argued that perforation was observed in patients with cecal diameters <10 cm.

By 2015 it had become evident, that the two forms of colonic pseudo-obstruction, namely acute and chronic, comprised two entirely different entities which require different treatment (Bernardi et al. 2015). It was argued that surgery would be performed too often in patients with a chronic dilatation, which does not necessarily pose a threat. A timely exclusion of a mechanical obstruction was advised in both cases, since both of them showed a potential for the development of complications.

1.2 Physiology

The human gut and, subsequently, the human colon are largely controlled by the enteric or intrinsic nervous system (ENS), which mostly acts independently of the autonomous nervous system (ANS), but can be influenced by it via many autonomic afferent and efferent pathways, mainly through the vagus nerve and prevertebral ganglia.

The ENS is comprised of a system of neurons that regulate the function of the gastrointestinal tract and coordinates absorption, secretion, blood flow and motility of the human gut. It contains an estimated 10^8 neurons, which comprise two major ganglion-plexuses: the myenteric plexus (Auerbach’s plexus), situated between the muscular layers of the intestinal wall and the submucosal plexuses (Meissner’s plexus), which are associated with the intestinal mucosa (figure 1).

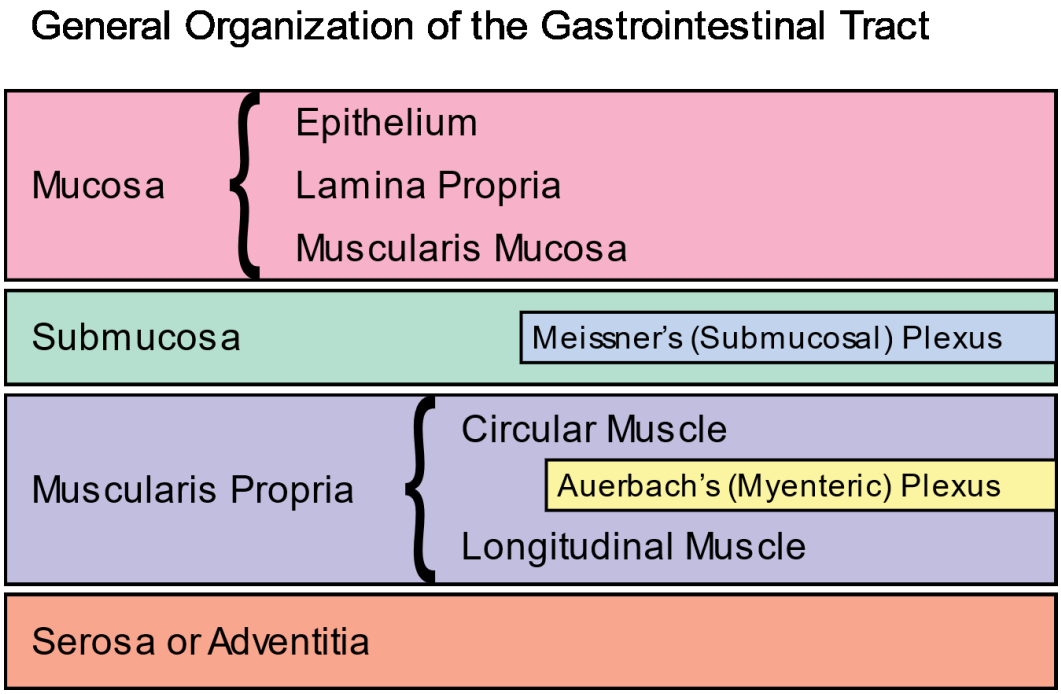

Figure 1. Organization of the GI tract
Source: Wikimedia. https://upload.wikimedia.org/wikipedia/commons/f/fb/GI_Organization.svg

The targets of these neurons are muscle, endocrine, secretory and inflammatory cells, as well as microvasculature. Mechanical distention of the gut wall as well as mucosal stimulation by the passage of food triggers those neurons and leads to secretion of a wide array of mediating factors.

Coordination of the gastrointestinal tract involves a complex and not entirely understood interaction between numerous neuroactive mediators, receptors, ion channels, hormones and other transmitters. Acetylcholine and serotonin have been identified as important neurotransmitters among others, such as adrenaline, vasoactive intestinal peptide, adenosine triphosphate (ATP) and others.

1.3 Pathophysiology

There is strong evidence to support that the main cause of the syndrome is an imbalance of the autonomous nervous system, namely an increased sympathetic and simultaneously a reduced parasympathetic activity (Bernardi et al. 2015, Figure 2). The result of this imbalance is a reduction in bowel motility and a consequent inability of

the colon to propel feces and flatus forward. This abnormal bowel motility eventually leads to colonic dilatation and thus begins the cascade of problems related to the syndrome.

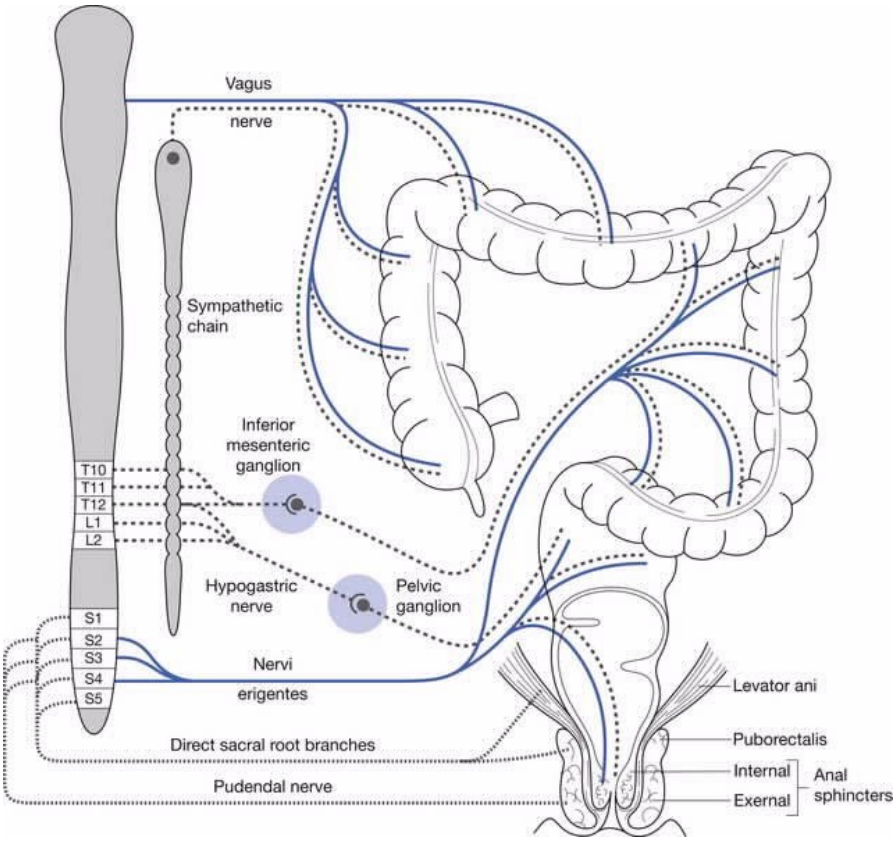

Figure 2. Colonic innervation
Source: Musculoskeletal Key. https://musculoskeletalkey.com/neurogenic-bowel-dysfunction-and-rehabilitation

According to Laplace´s Law, *"the transmural pressure required to cause distension in a tubular structure is proportional to the wall thickness and surface wall tension, and inversely proportional to its radius"* (Figure 3). This means that an organ with a large diameter and low surface tension, such as the colon, requires but a small change in intramural pressure to cause further dilatation. In other words, an already dilated colon is in danger of becoming more and more expanded and thus vulnerable, following just small pressure changes. And as the colon expands, its wall becomes more and more stretched, which in turn compromises its blood supply on the capillary level. This can subsequently lead to wall edema and an increase in bacterial growth within the wall, which in turn can migrate through the weakened colonic wall in the abdominal cavity,

or lead to a perforation of the bowel. In both cases the result is a life-threatening peritonitis. The cecum, being the colon segment with the largest diameter typically, is also the point where the tensile strength will be exceeded sooner. This explains why this particular colonic segment is most often affected by this autonomic malfunction.

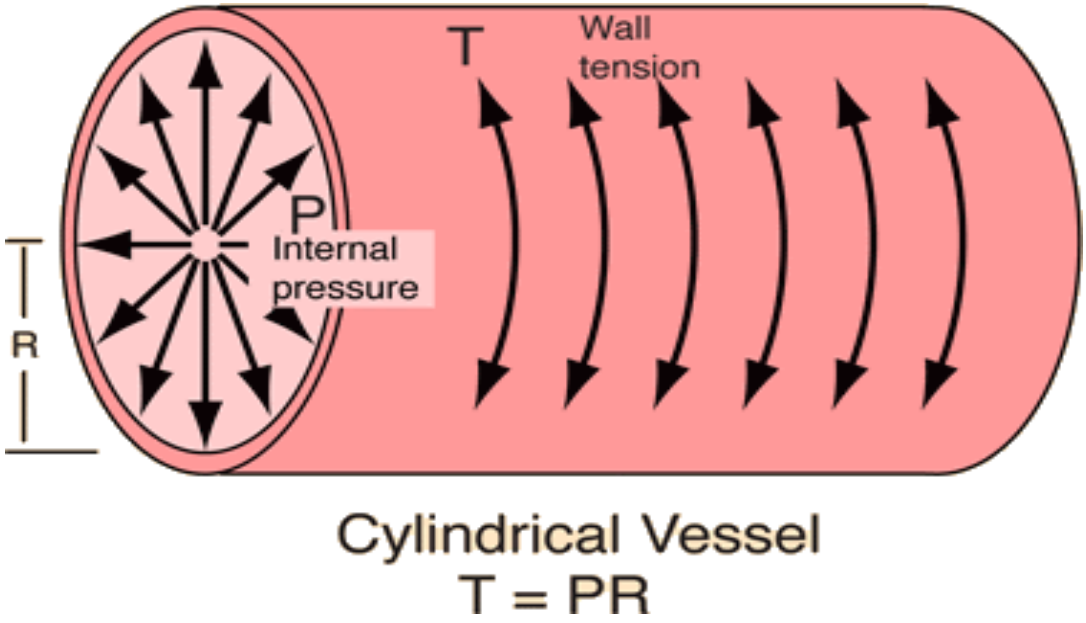

Figure 3. Laplace's Law in tubular structures. T: tension; P: internal pressure; R: radius Source: HyperPhysics © 2016 Georgia State University. http://hyperphysics.phy-astr.gsu.edu/hbase/ptens3.html

1.4 Epidemiology

Ogilvie's syndrome is a rare condition and most frequently occurs in critically ill patients with numerous comorbidities and is associated with certain underlying conditions, such as cardiovascular, respiratory, neurological, obstetric, metabolic, orthopedic, post-traumatic, post-surgical and infectious or inflammatory insults (Valle and Godoy 2014). The overall incidence is calculated at approximately 100 cases per 100.000 hospital admissions (Ross et al. 2016). As human life expectancy slowly increased in the last decades, so did the mean age of the population and, consequently, the age of patients treated in hospitals. Older patients have often more underlying comorbidities and/or compromised organ functions and are therefore more susceptible to complications

resulting from acute medical conditions or in the immediate aftermath of a surgical procedure.

1.5 Diagnosis of Ogilvie's syndrome

The diagnosis is usually based on clinical and radiographic findings and is, therefore, rather easy to miss at an early stage. One of the reasons is the rarity of the syndrome and the consequent lack of experience of many physicians thereof. The early symptoms include flatulence, increased abdominal distension and/or pain, nausea and vomiting and a lack of passage of stool. However, absence of one of more of these symptoms does not exclude a pseudo-obstruction (Bardsley et al. 1974).

Ultrasound is a quick and cheap diagnostic tool and it is widely available nowadays, even in the most remote clinics, however small. It is unfortunately rarely helpful, due to the large amounts of air within the colon. The small bowel can sometimes be visualized and it often appears normal, without signs of an ileus. The left hemicolon could also appear normal, as the syndrome usually affects the cecum and/or right hemicolon (Figure 4).

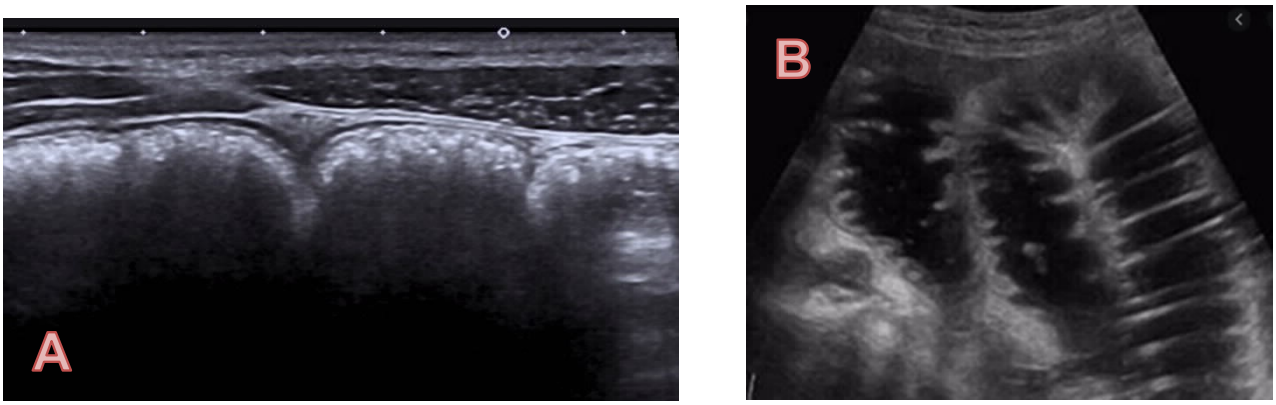

Figure 4: Abdominal ultrasound. A: gas filled colon, obstructing the visualisation of structures underneath. B: small intestine ileus (usually filled with liquid)
Source: A: Brown Emergency Medicine (http://brownemblog.com/blog-1/2017/3/3/pocus-for-appendicitis), B: Ultrasound Cases (https://www.ultrasoundcases.info/obstruction-and-ileus-4241/)

In such patients a plain abdominal radiography could help with the diagnosis through demonstration of a distended colonic segment (Figure 5). Small intestine dilatation can also be excluded here, through the absence of the typical gas-fluid levels. Abdominal radiographs, however, have diagnostic limitations and are able to show only nonspecific findings of colonic dilation.

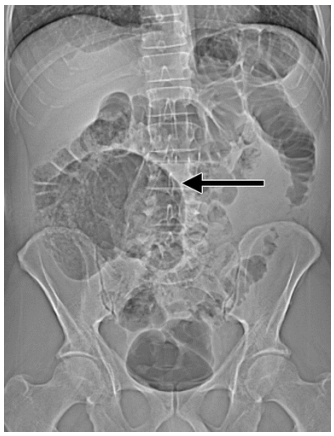

Figure 5: Cecum dilatation with normal appearing colon distally. Source: Jaffe and Thompson 2015; doi: 10.1148/radiol.2015140916

A barium enema represents another diagnostic modality and was previously quite common. It can help to confirm a segmental colonic dilatation and exclude a mechanical cause for it. However, it should be avoided upon clinical suspicion of colonic perforation, since it can lead to a further deterioration of the already compromised patient.

Computer tomography is currently the gold standard for the detection of Ogilvie's syndrome, as it may reveal a largely distended colonic part, without evidence for a mechanical cause (Figure 6). Choi et al. argues that CT may be more helpful in accurately measuring the cecal diameter than a plain abdominal radiography, since feces or fluid in the colon can obscure the colonic margins in an x ray (Choi et al. 2008).

An early recognition is albeit critical for the successful treatment of the patient, since a delay in treatment onset is associated with an increase in life-threatening complications, such as bowel ischemia and perforation or abdominal compartment syndrome (Valle and Godoy 2014).

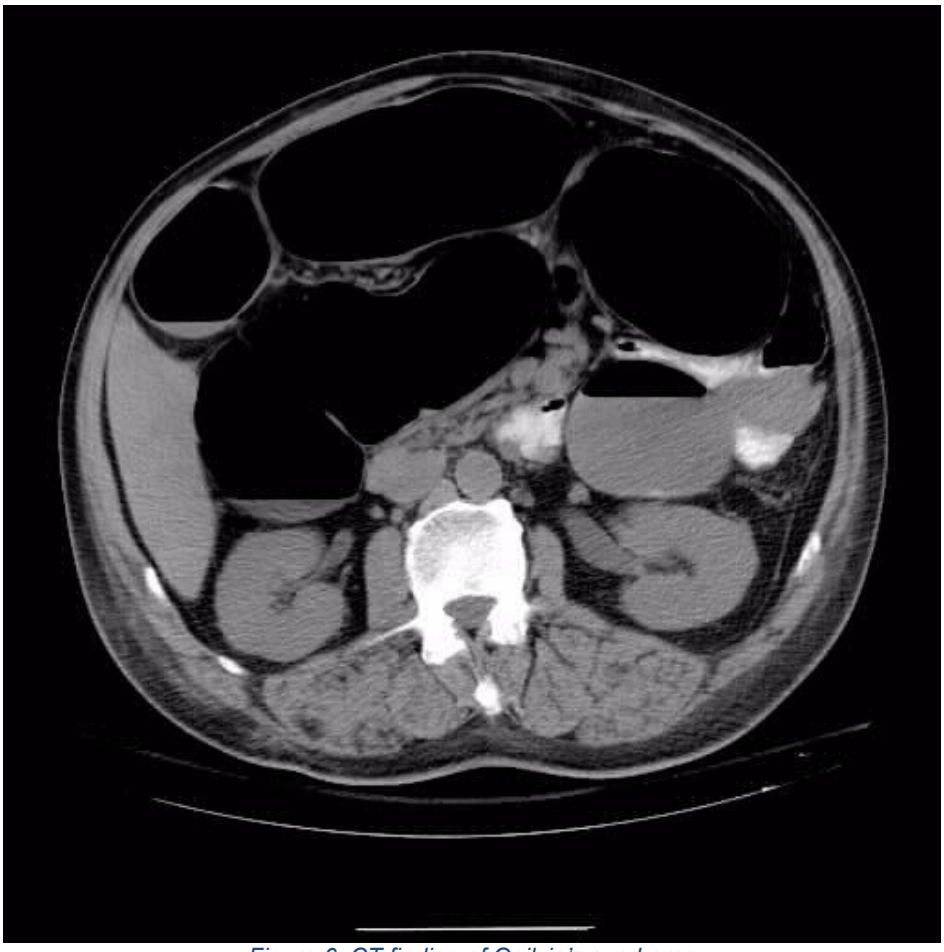

Figure 6. CT finding of Ogilvie's syndrome
Case courtesy of Radswiki, Radiopaedia.org (https://radiopaedia.org/cases/11684/studies/32135?lang=us)

1.6 Management

The initial management relies heavily on conservative measures and includes gastric decompression via placement of a nasogastric tube, repeated enemas, rectal tube placement, restoration of potential electrolyte imbalances, limiting of antiperistaltic drugs, such as opiates or calcium antagonists, and treatment of the underlying condition, which may have caused or triggered the syndrome or may play an active role in maintaining it. Monitoring of the patient and repeated clinical and radiological assessment, as well as blood tests are essential, in order to detect a clinical deterioration requiring a therapy escalation as soon as possible.

If the symptoms persist in spite of all the aforementioned measures, prokinetic agents such as neostigmine for colonic stimulation, as well as erythromycin or metoclopramide, which enhance upper gastrointestinal peristalsis, can be invoked with

rather few adverse effects (Lewis et al. 2016, Ponec et al. 1999). Erythromycin, for example, has been known to cause severe ventricular arrhythmia (Schoenenberger et al. 1990), although this has been observed at a higher dose, than the one used to promote gut motility. Additionally, wide use of erythromycin could potentially lead to development of microbial resistance to antibiotics. Both erythromycin and metoclopramide are also associated with tachyphylaxis (Nguyen et al. 2007). Neostigmine, on the other hand, through its parasympathomimetic activity, may induce bradycardia, especially in patients with underlying heart conditions, or those receiving beta blockers. It also results in an increase of airway secretions, as well as reactivity of the bronchial system and may thus lead to an exacerbation of active bronchospasm (Ponec et al. 1999). Since it is mainly cleared through renal excretion, patients with impaired kidney function may suffer from prolonged vagomimetic activity after administration of the drug (Webb et al. 1995).

Furthermore, colonoscopic decompression of the large bowel, with or without placement of a decompression tube, has also proven effective. Once the dilated colonic segment has been reached, a wire is placed through the endoscope. The endoscope is retrieved and a decompression tube is placed “over-the-wire” with or without the assistance of x-rays (Figure 7). However, this intervention is associated with a rather high recurrence rate and a perforation incidence of two percent. The latter is mainly an effect of the often unprepared bowel, which impairs endoscopic vision and increases intestinal wall strain through repeated irrigation and prolonged insufflation. It should therefore be performed by experienced endoscopists and, when possible, not in an emergency setting, but rather in a controlled environment and optimally after bowel preparation is previously attempted (De Giorgio and Knowles 2009).

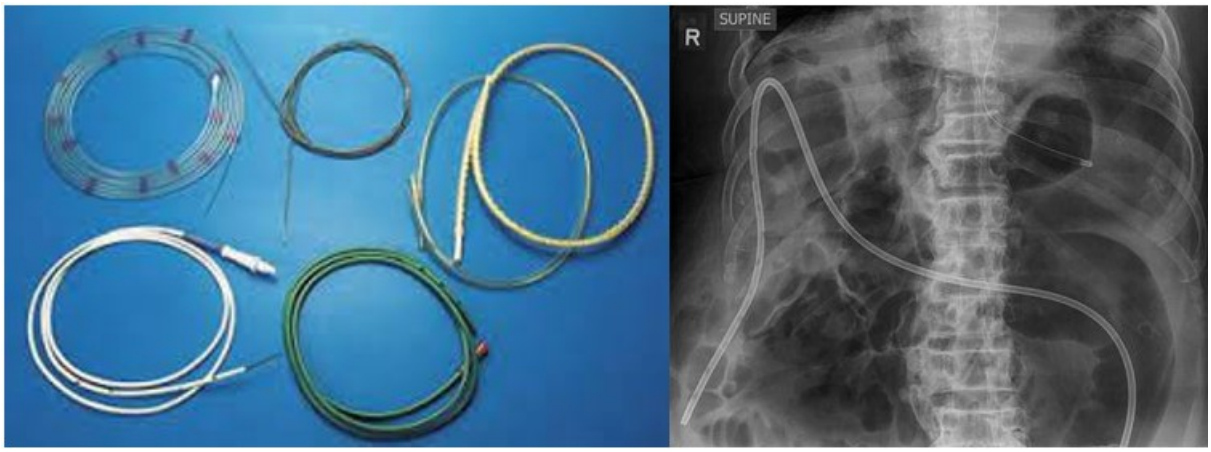

Figure 7. Left: various decompression tubes. Right: A decompression tube reaching up to the cecum. Source: left thieme-connect.de (https://www.thieme-connect.de/products/ebooks/lookinside/10.1055/b-0034-59905); right: Diagnostic and Therapeutic Procedures in Gastroenterology; © Springer International Publishing AG 2018

Some authors suggest the placement of a percutaneous endoscopic cecostomy (PEC) for patients after unsuccessful conservative and pharmacological treatment (Figure 8). The technique is similar to placement of a percutaneous endoscopic gastrostomy (PEG), the main difference and challenge being reaching the cecum through a dilated and -as mentioned above- often inadequately prepared colon. The relatively high incidence of complications, however, has deemed this method unpopular (Bertolini et al. 2007). These include bleeding, granuloma formation, local infection, necrosis of the colonic wall and subsequent peritonitis.

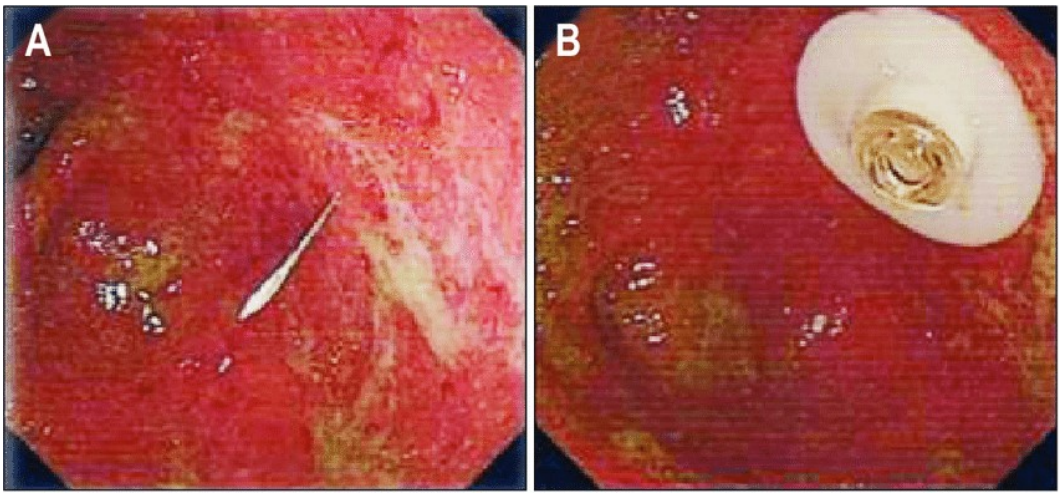

Figure 8. A: the needle is inserted percutaneously in the cecum under endoscopic control. B: PEC in place Source: Ni 2016; doi:10.5009/gnl15456

Surgery remains to this day an ultima ratio, when all other treatments have proven unsuccessful or when signs of peritonitis or bowel perforation are evident. It is associated with an increased mortality, partially since most patients are heavily compromised at the time of operation.

1.7 Rationale and aim of the study

Though the syndrome itself, as well as the numerous conservative, pharmacological and endoscopic approaches and their respective limitations have been widely described (Wells et al. 2017, Vogel et al. 2016, Bernardi et al. 2015), there has been little to no data regarding exclusively surgically treated patients and their outcomes to date. The aim of this study is to examine the postoperative outcomes of surgically treated patients with Ogilvie's syndrome in an intensive care unit (ICU) setting in the department of surgery of the university clinic of Mannheim between 2009 and 2016. Emphasis was placed on the postoperative complications, as well as on the survival of patients.

2 MATERIALS AND METHODS

2.1 Patient sample

The study was accomplished in two parts. The first one was retrospective and involved the analysis of consecutive Ogilvie's-syndrome patients selected from the electronic clinical record database of the Medical Faculty of Mannheim within a period of 6.5 years (01/2009 – 07/2015). This resulted in a total of 65 patients. To increase patient sample size and data validity, we started a prospective registry of consecutive patients with Ogilvie's syndrome as these were treated in our surgical department and on the ICU. Seventeen consecutive patients were recruited in this fashion between 07/2015 and 12/2016, bringing the total population up to eighty-two.

For the first part, data of all past operations performed in the surgical clinic were gathered from the hospital's electronic clinical record system, based on search filters for relevant diagnoses (ICD-10) or procedure codes (Table 1). Each case was then reviewed in detail (personal imaging review, evaluation of imaging reports and operative reports, data extraction from electronic hospital database) to identify patients fulfilling the criteria of Ogilvie's Syndrome, namely acute dilatation of the colon without evidence of an organic obstruction. Since the diagnosis is mostly radiological/clinical, emphasis was placed either on relevant preoperative radiological imaging or intraoperative findings, as described in the operating room (OR) reports.

TABLE 1. ICD-10 and procedure codes (OPS-CODES) used for recruiting of patients

Diagnoses as per ICD-10 Codes*	K55: Vascular disorders of intestine K56: Paralytic ileus and intestinal obstruction without hernia K59: Other functional intestinal disorders K63: Other diseases of intestine K91: Postprocedural disorders of digestive system, not elsewhere classified
Procedure codes (OPS-Codes)**	5-450.2: Incision of the colon 5-455: Partial resection of the colon 5-456: (subtotal) colectomy and/or proctocolectomy 5-459: Bypass-anastomosis of the colon

**ICD-10-GM, Version 2021*
***as described in the official "German procedure classification" by the German Institute of Medical Documentation and Information, Version 2021 (https://www.icd-code.de)*

For the second, prospectively collected part of the study population (07/2015 – 12/2016), patients were consecutively recruited as they were diagnosed with Ogilvie's Syndrome in the surgical clinic and surgical ICU in a similar fashion.

Patients with tumor disease were excluded, as this could be a potential cause for the bowel distention. Likewise, we excluded patients with a clear mechanical obstruction, such as volvulus, or intraabdominal adhesion bands. Moreover, excluded were also patients with ischemic bowel disease or non-occlusive mesenteric ischemia (NOMI), as it was impossible to differentiate if the ischemia was the cause for dilatation, or vice versa. Furthermore, patients with radiological or intraoperative findings of a bowel perforation without previous evidence of colonic dilatation were also excluded, as the perforation could not be attributed to Ogilvie's Syndrome with certainty (Figure 9).

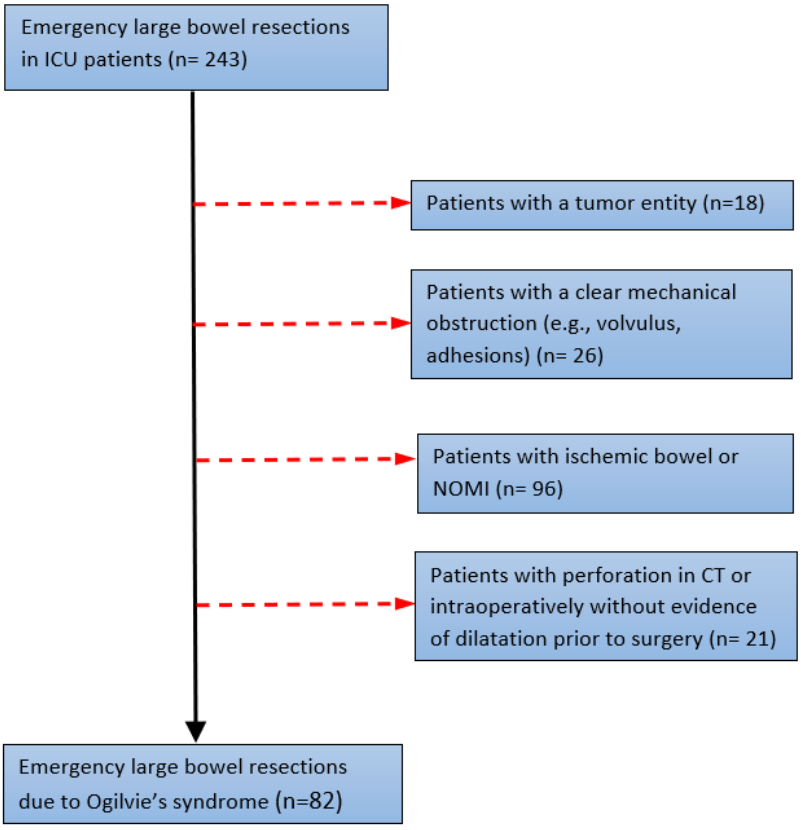

Figure 9. Flowchart of patient inclusion

The American Society of Anesthesiologists' physical status classification (ASA-Score) was obtained from the anesthesiologic reports at the time of index surgery. Organ failure was determined as follows: respiratory failure related to the patient being already intubated prior to index surgery; circulatory failure related to the need for continuous noradrenaline administration, in order to maintain an adequate blood pressure; kidney failure was diagnosed as an increase in serum creatinine by ≥0.3 mg/dl within 48 hours, or ≥1.5 times the patient baseline within the prior 7 days, or by a urine volume less than 0.5 ml/kg/h for 6 hours straight; liver failure was diagnosed as a triple-fold increase in serum transaminases or a prolonged prothrombin time by 4-6 seconds or more.

2.2 Statistical analysis

The statistical analysis was explorative in this observational study and it was performed under supervision of the statistical department of the University Medical Center of Mannheim. Quantitative variables are presented by mean values ± standard deviation

(for normally distributed data) or by median value and range. For qualitative parameters, absolute and relative frequencies are given. In order to compare two groups regarding quantitative parameters, Mann-Whitney-U test was used. For approximately normally distributed values (e.g. patients' age), two sample t test was used instead. In order to compare two groups regarding relative frequencies, Chi-squared test or Fisher's exact test were used, as deemed appropriate. The result of a statistical test was considered as significant for $p < 0.05$. All statistical calculations were done using Statistical Analysis System (SAS) software, release 9.3 (SAS Institute Inc., NC, USA).

2.3 Ethic approval

The study was reviewed by the ethical committee of the University of Mannheim, department of the faculty of Heidelberg. The data acquisition began after the aforementioned committee's approval (No. 2017-559N-MA).

3 RESULTS

3.1 Patient characteristics

Preoperative patient characteristics are shown in Table 2. The study included 82 patients (58 male, 24 female). Patient age ranged from 23 to 87 years, with a mean of 62.3 years. Eighteen of those patients were reported having an ASA-Score of 3 at the time of operation, according to the anesthesiology reports. Forty-five had a score of 4, whereas 10 had a score of 5. Nine patients lacked documentation of the ASA-Score at the specified time.

3.2 Underlying disease and cecum diameter

The primary disease (reason of hospital admission) was general surgery in nine of those patients (11%), neurosurgical in fourteen (17.1%), orthopedic in fourteen (17.1%), cardiopulmonary in thirty-one (37.8%), urological in one (1.2%), gynecological in one (1.2%), acute pancreatitis in three (3.6%) and miscellaneous in further nine patients (11%).

The median time interval between diagnosis of Ogilvie's Syndrome and surgical therapy was 8 hours (range 1 to 61 hours). The median diameter of the cecum was 10 cm (range 5 to 15 cm) (Figures 10-12).

At the time of indication for surgery, 75.6 percent of the patients were already intubated, signaling a respiratory failure. Sixty-seven percent required continuous intravenous adrenaline administration to maintain an adequate blood pressure, whereas 50 percent of the patients showed an acute renal insufficiency and as many as 17 percent an acute liver failure.

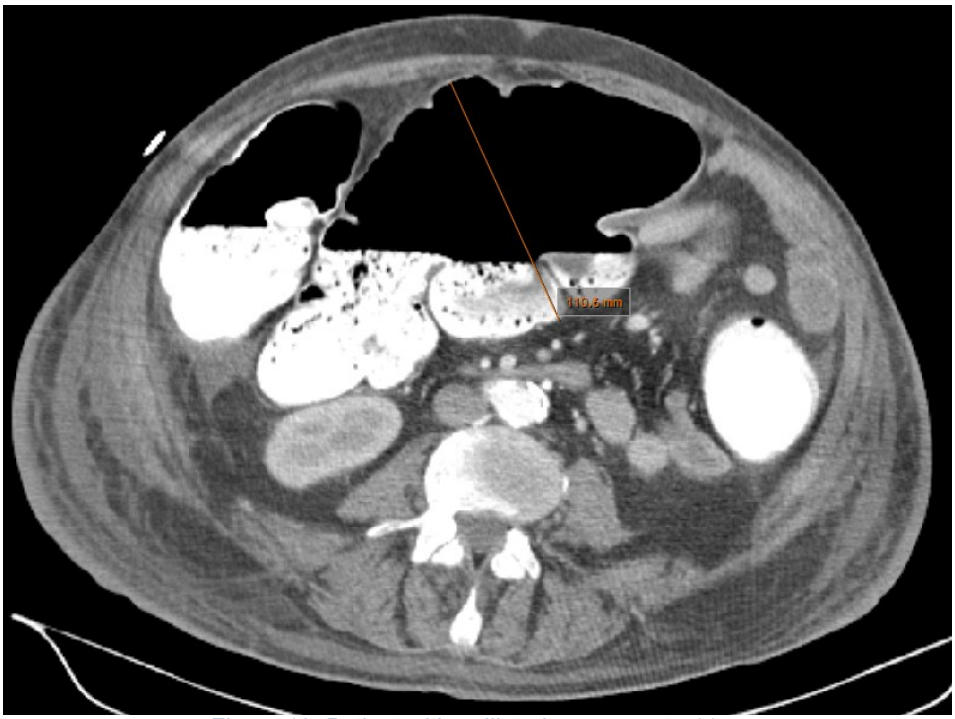

Figure 10. Patient with a dilated cecum up to 11cm
Source: electronic clinical record database of the University Medical Centre Mannheim

Figure 11. Patient with a dilation reaching up to the splenic flexure (cecum: 7.9cm, transversum: 4.8cm)
Source: electronic clinical record database of the University Medical Centre Mannheim

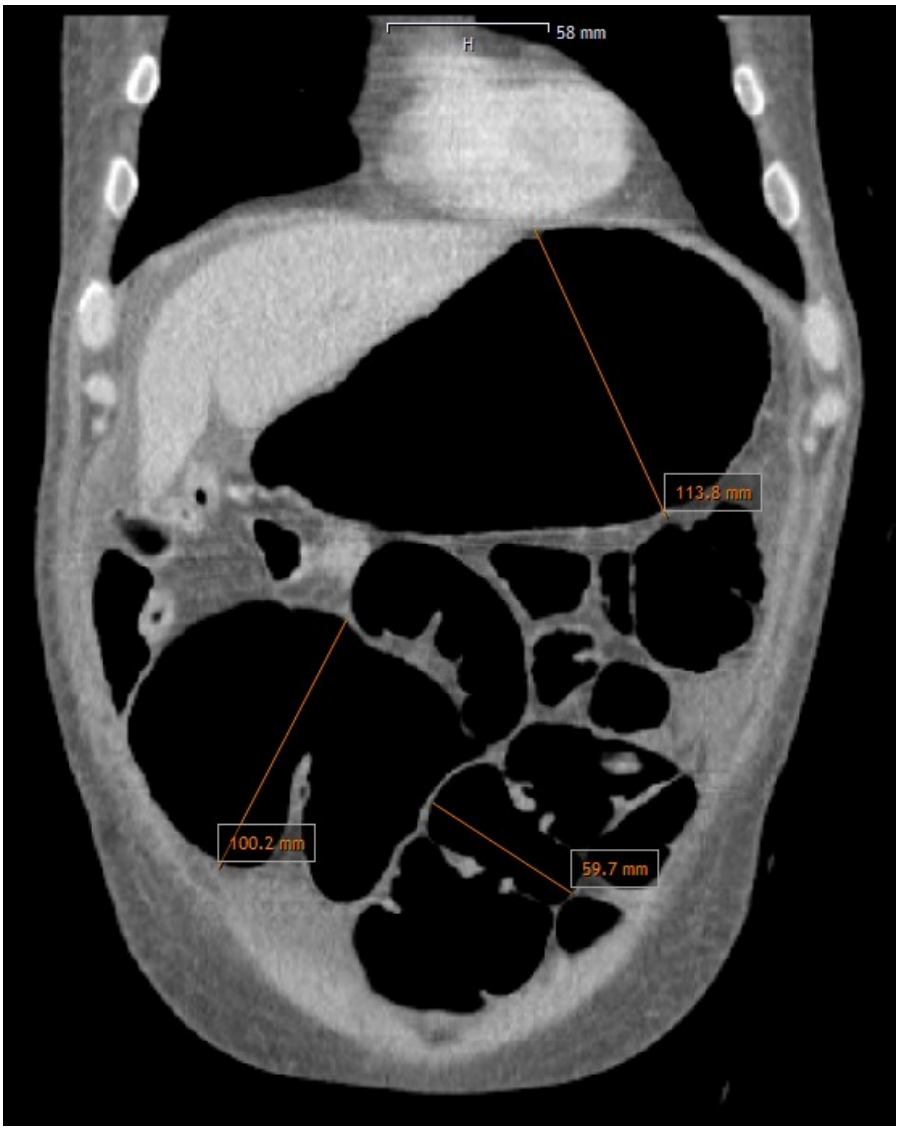

Figure 12. Patient with a dilation of the entire colon (cecum: 10cm, transversum: 11.4cm, sigmoid: 6cm). Source: electronic clinical record database of the University Medical Centre Mannheim

3.3 Type of surgical procedure

The following surgical procedures for treatment of Ogilvie's syndrome were performed (Table 3): six percent of the patients received a cecostomy, whereas 49 percent underwent a right hemicolectomy and 45 percent a subtotal colectomy. Regarding the intraoperative findings, a colonic perforation was documented in 17 percent of the patients and 30 percent had a peritonitis. Typically for the syndrome, seventy-nine percent of the patients had a pathologically dilatated cecum up to the splenic flexure, whereas by as many as 21 percent of the patients the dilatation exceeded this point aborally, up to the rectosigmoid junction.

TABLE 2. Preoperative patient characteristics

Sex (male/female)		58/24
Age (years)		
Median		62.3
Range		23-87
Cecal diameter in preoperative diagnostic workup* (cm)		
Median		10
Range		4.5-15
Time interval between diagnosis of Ogilvie's syndrome and surgery (hrs)		
Median		8
Range		1-61
ASA Score at time of indication for surgery**	3	18 (22.0%)
	4	45 (54.9%)
	5	10 (12.2%)
Main underlying disease leading to ICU-admission	General surgery	9 (11.0%)
	neurosurgical	14 (17.1%)
	orthopedic/trauma	14 (17.1%)
	gynecologic/urologic	2 (2.4%)
	cardiopulmonary	31 (37.8%)
	other	12 (14.6%)
Organ failure at time of indication for surgery***	Respiratory	62 (75.6%)
	Circulatory	55 (67.1%)
	Kidney	41 (50.0%)
	Liver	14 (17.1%)
Extent of bowel dilatation at time of surgery****	Cecum/C. ascendens	21 (25.6%)
	Hepatic flexure	7 (8.5%)
	C. transversum	22 (26.8%)
	Splenic flexure	10 (12.2%)
	C. descendens	5 (6.1%)
	Rectosigmoidal junction	11 (13.4%)

**: abdominal CT-Scan, plain abdominal radiography, or intra-operative finding (no data availabe n=6)*

***: data-source: anaesthesiologic report at time of surgery (no data available n=9)*

**** multiple options possible (no data available n=2)*

***** no data available (n=6)*

TABLE 3: Intra-operative findings during index surgery for Ogilvie's syndrome

Presence of colonic perforation intra-operatively*		14 (17.1%)
Presence of purulent peritonitis intra-operatively*		24 (29.2%)
Type of first surgical treatment	Cecostomy	5 (6.1%)
	Right hemicolectomy/Hartmann	40 (48.8%)
	Subtotal colectomy/Hartmann	37 (45.1%)

** findings as indicated in surgical reports. Not all surgical reports reported on presence or absence of perforation or peritonitis.*

3.4 Morbidity and mortality

Data for post-operative morbidity and in-hospital mortality are shown in Tables 4a/b: Postoperative overall morbidity was 62.2 percent; this included amongst others: two percent insufficiencies of the rectal pouch (Hartmann's procedure), sixteen percent ostomy complications, twenty-three percent intraabdominal abscess formation or sepsis, ten percent postoperative bleeding requiring blood transfusion or surgical revision. Sixty-one percent of the patients underwent further reoperations, either due to complications or as part of a second look procedure.

The in-hospital mortality was almost 54 percent. Median time interval between the first operation for Ogilvie's syndrome and the time of death was 6 days (range 1 hour to 96 days). Mortality was significantly associated with underlying circulatory (p=0.0007) or pulmonary (p=0.003) failure at the time of operation, this being determined by the patient being already intubated or treated continuously with intravenous adrenaline respectively, as well as with the ASA Score at the time of operation (p=0.03). In the postoperative period, a secondary hemorrhage was significantly associated with increased mortality (p=0.03). We found no statistically significant association between sex (p = 0.6), perioperative extracorporeal membranic oxygenation (ECMO) therapy (p = 1), interval between diagnosis and operation (p = 0.4), extent and localization of the colonic dilatation (p = 0.7 and p = 0.6 respectively), or type of surgical procedure (p = 1) and post-operative mortality (table 5).

TABLE 4a: Outcome of surgical therapy

Overall morbidity	Patients with any complication*	51 (62.2%)
	Insufficiency of Hartmann‘s stump	2 (2.4%)
	Ostomy complications	13 (15.9%)
	Sepsis/ intraabdominal abscess	19 (23.2%)
	Postoperative bleeding	8 (9.8%)
	Revisions/Re-operation(s)	50 (60.1%)
Re-operations after index surgery	1-2 re-operations	22 (26.8%)
	3-5 re-operations	17 (20.7%)
	>5 re-operations	11 (13.4%)
	Total	50 (61.0%)
In-hospital mortality		44 (53.7%)
Surgery-specific post-operative mortality	Cecostomy (n=5)	3 (60.0%)
	Right hemicolectomy (n=40)	21 (52.5%)
	Subtotal colectomy (n=37)	20 (54.1%)
Interval between index surgery and time of in-hospital death		
Median		6 days
Range		1h - 96d

** multiple complications per patient possible*

TABLE 4b: Surgery-specific post-operative morbidity

Cecostomy (n=5)	Ostomy complications	2 (40.0%)
	Sepsis/ intraabdominal abscess	1 (20.0%)
	Postoperative bleeding	0
	Revisions/Re-operation(s)	4 (80.0%)
Right hemicolectomy (n=40)	Insufficiency of Hartmann‘s stump	0
	Ostomy complications	6 (15.0%)
	Sepsis/ intraabdominal abscess	11 (27.5%)
	Postoperative bleeding	3 (7.5%)
	Revisions/Re-operation(s)	24 (60.0%)
Subtotal colectomy (n=37)	Insufficiency of Hartmann‘s stump	2 (5.4%)
	Ostomy complications	5 (13.5%)
	Sepsis/ intraabdominal abscess	8 (21.6%)
	Postoperative bleeding	5 (13.5%)
	Revisions/Re-operation(s)	22 (59.5%)

TABLE 5: Mortality-associated factors

Circulatory failure at time of operation	p=0.0007
Respiratory failure at time of operation	p=0.003
ASA Score	p=0.03
Postoperative hemorrhage	p=0.03
Sex	p=0.6
Perioperative ECMO therapy	p=1
Interval between diagnosis and operation	p=0.4
Extent of the colonic dilatation	p=0.7
Localization of the colonic dilatation	p=0.6
Type of surgical procedure	p=1

4 DISCUSSION

Main findings and resulting questions

Main findings of the study were a very high overall postoperative morbidity of 62% and an in-hospital mortality of more than every second patient treated surgically for Ogilvie's syndrome. This is mainly explained by severe organ function insufficiency and the multimorbid patient population at the time of indication for surgery.
Moreover, these results pose several questions: Under which conditions is surgical therapy of Ogilvie's syndrome an acceptable therapeutic option? Should surgery be abandoned or - in contrary - be indicated much earlier in the disease course to prevent progressive multi-organ failure and improve patient outcomes?

Early recognition is key to success

Ogilvie's syndrome remains a challenging clinical entity. Since its first description by Sir William Heneage Ogilvie in 1948, numerous studies have targeted this subject. Yet, the pathophysiology remains largely obscure. It is suggested that an imbalanced extrinsic autonomic innervation plays a major role in the disturbance of the proper absorption and propulsion through the gastrointestinal tract. An increased sympathetic activity, as often seen in critically ill patients, is thought to provoke a relaxation of the proximal colon and/or a reduction in the parasympathetic tone causes a functional obstruction of the distal colon (Durai et al. 2009). Once the dilatation has occurred, there is experimental evidence suggesting a self-maintenance of the colonic contractile inhibition through stretch-sensitive mechanoreceptors in the gut wall (Hughes et al. 1999). Trevisani concluded that the most plausible etiology of Ogilvie's syndrome may be parasympathetic suppression and not sympathetic over-activity, as patients treated with neostigmine, a drug enhancing parasympathetic activity through binding with acetylcholinesterase, showed a clinical resolution of their symptoms (Trevisani et al. 2000).

The early recognition of this syndrome is of major importance, as it can lead to a rapid deterioration of the patient with severe complications, such as sepsis, abdominal compartment syndrome, multi-organ dysfunction and perforation of the colonic wall. The syndrome is mostly observed in critically ill patients requiring treatment in intensive care units. According to a review of 400 cases (Vanek et al. 1986), the leading associated conditions tended to be ones relating to trauma, infection, cardiac disease and obstetrics/gynecology. Those numbers, however, refer to the diagnosis of the syndrome, regardless of the patients' clinical outcome and most of those patients never had to be surgically treated for this syndrome. In this series, which involved patients eventually operated on this diagnosis, there was a prevalence of cardiopulmonary diseases with 37.8 percent, followed equally by orthopedic and neurosurgical (17 percent each) and lastly by surgical patients (11 percent) as leading associated conditions. This suggests, for example, that the majority of obstetrics/gynecology patients may eventually not be associated with surgical treatment, as the conservative treatment tends to be successful. On the other hand, however, patients with an impaired circulatory and/or lung function - namely the ones requiring catecholamine support or those under mechanical ventilation respectively - tend to be the ones who eventually require a surgical treatment.
In our series, time from diagnosis to surgery ranged from 1 to 61 hours with a median of 8 hours. There was no statistical significance between mortality and time to surgery, mainly due to the fact that all patients were being treated in an ICU and were therefore constantly monitored. Once signs of clinical deterioration under conservative, medical and/or endoscopic treatment were observed, a surgical approach was invoked in a timely manner.

The diagnosis is based largely on clinical and radiological findings. It is mostly characterized by abdominal distention, pain, nausea and vomiting, as well as the absence of flatus and stool passage in as many as 60 percent of the patients (De Giorgio and Knowles 2009). A plain abdominal radiography can show degrees of colonic dilatation, mainly involving the proximal colon (Johnson et al. 1985). It can give an indication of the colonic diameter and also show signs of perforation, e.g. free air under the diaphragm. Ultrasound of the abdomen provides limited diagnostic options, due to the large amounts of air trapped within the colon. An abdominal computer tomography with rectal contrast enema should be performed whenever possible, in

order to accurately exclude a mechanical cause for the distention, such as a tumor, adhesions or a volvulus. A CT scan is considered to be more helpful than abdominal radiography for accurate measurement of the colonic diameter, as fluid or fecal material can obscure the margin of colon on radiographs (Choi et al. 2008). Moreover, a CT scan can reveal signs of intramural gas in the colonic wall, which mostly portends a life-threatening situation requiring urgent surgery. Furthermore, even small quantities of free air can be detected via a CT scan, whereas in a plain abdominal radiography this can be easily missed.

Treatment essentials

According to current best practice guidelines, initial treatment of Ogilvie's syndrome is conservative and includes fasting, nasogastric tube placement to relieve the stomach, replenishing of intravenous fluids, treatment of the underlying disease, electrolyte correction and occasionally a rectal tube placement (De Giorgio and Knowles 2009, Naveed et al. 2020, Alavi et al. 2021). Discontinuing of drugs impairing gut mobility, such as opiates or calcium channel blockers, should also be considered. The conservative treatment should not exceed 48-72h, since that is associated with a higher risk of complications (Saunders et al. 2007). Blood tests and plain abdominal radiographies should be performed every 12-24 hours in order to assess the colonic distention and detect a possible septic deterioration of the patient in due time. If there is no response within this time frame and the patient is clinically stable (without any evidence of organ failure), pharmacological treatment with neostigmine is indicated. Furthermore, colonoscopic decompression and tube placement may be indicated as interventional therapy (Alavi et al. 2021).

Diameter and duration: most important risk stratification factors

Cecum diameter seems to be of great importance, as this is most often the site where perforation occurs. According to La Place's law, the pressure required to stretch the walls of a hollow viscus decreases in inverse proportion to the diameter. The cecum,

being the segment with the largest diameter, will be the one where the tensile strength of the colon will be exceeded sooner. A cecal diameter of 9-12 cm has been considered a sign of impending perforation (Vanek et al. 1986). Vanek also showed a twofold increase in mortality when the cecal diameter exceeded 14 cm, as well as a fivefold increase when the delay in decompression of the colon was seven days or more after the diagnosis, compared with patients who received a decompression in less than four days. Another series reported a mean duration of distention of 6 days in patients where perforation occurred, compared with 2 days in those who did not (Johnson et al. 1985). Both of these studies suggested, that the risk of colonic perforation was more heavily associated with the duration of the distention than the absolute diameter of the cecum. This highlights the importance of an early recognition of Ogilvie's syndrome.
In our series, neither cecal/colonic diameter nor extent of colonic dilatation were found to be significantly associated with mortality. However, the documented diameter often refers to a plain radiography or computer tomography, which was performed hours or even a day or two before surgery. An initially detected "small" dilatation could therefore gain in extent in the time between diagnosis and surgery. Intraoperative findings were often described without an assertive centimeter specification, thus not allowing for an exact diameter documentation. It should be also noted, that our patient cohort involved multimorbid patients, who tend to deteriorate rapidly. The time frame for conservative, pharmaceutical and/or endoscopic treatments is consequently quite often extremely short.

Step-up approach in clinical management: Step-1: pharmacological therapy

Neostigmine is a reversible acetylcholinesterase inhibitor, which allows for an increased binding of acetylcholine and consequent stimulation of muscarinic parasympathetic receptors, thereby enhancing colonic motor activity, inducing colonic propulsion and accelerated transit (Law et al. 2001). It remains the mainstay of treatment for patients with Ogilvie's syndrome, as it usually succeeds in rapidly decompressing the colon when administered intravenously (Ponec et al. 1999). Success rates of up to 94 percent have been found with up to 27 percent recurrence from three randomized controlled trials (Ponec et al. 1999, Amaro and Rogers 2000, van der Spoel et al. 2001). The most common adverse effect is abdominal pain, in the

form of cramping. It can also cause excessive salivation and vomiting, due to parasympathetic hyperactivity. Sporadic symptomatic bradycardia needing atropine has also been reported, it is therefore suggested that the patient be monitored during and shortly after the drug administration. Other prokinetic agents include metoclopramide and erythromycin. Metoclopramide is a selective D2 (dopamine) receptor antagonist that enhances peristalsis in the upper gastrointestinal tract, whereas erythromycin acts locally to enhance the release of motilin from enterochromaffin cells of the duodenum. Motilin itself causes contraction of the duodenum and gastric antrum, improving peristalsis in the small intestine. (Weihrauch et al. 1979). A meta-analysis of thirteen randomized controlled studies, involving a total of 1341 patients, concluded that administration of prokinetic agents in patients who are enterally fed in an ICU setting is related to an improved feeding intolerance and lower gastric residual volumes (Lewis et al. 2016). Lastly, a randomized, placebo-controlled trial of 30 patients showed that administration of polyethylene glycol in patients after initial resolution of colonic dilatation due to Ogilvie's syndrome, may decrease recurrence rates after a therapeutic intervention (Sgouros et al. 2006)
In our patient sample, all patients (100%) had had unsuccessful treatment with pharmacological therapy before surgery. Since surgical therapy was an inclusion criterium, patients who did not require surgery were naturally excluded.

Step-2: The role of endoscopy

In cases where medical therapy fails or is contraindicated, endoscopy offers effective intervention with advanced techniques, such as decompression tubes or percutaneous endoscopic cecostomy, providing effective results (Jain and Vargas 2012). Colonoscopy alone, involving the suction of excessive flatus and stool from the colon, may lead to successful colonic decompression in as many as 70 percent of the patients (Rex et al. 1997, Jetmore et al. 1992). In such patients, the colonoscope should be advanced at least up to the right colonic flexure.

The procedure is however associated with a recurrence rate of up to 40 percent, which can be further reduced by placement of a decompression tube at the time of the intervention. There exists a wide variety of decompression tubes, with varying

diameters, side-holes or means to stay in position. Most of them can be placed over a wire, which is placed through the endoscope, and their position can be controlled with an x-ray at the time of placement.

Ultimate clinical success, defined by a reduction in radiographically measured cecal diameter after one or more procedures, is reported to range from 73 to 88 percent (Saunders and Kimmey 2005, Wegener and Borsch 1987, Harrison et al. 2010). In such patients, however, colonoscopy can be quite challenging, as it is often performed without previous bowel preparation since oral laxatives have already failed to promote bowel movement. Furthermore, insufflation of the colon should only be undertaken cautiously with carbon dioxide, since the risk of perforation in such patients is reported to be as high as 3 percent (Geller et al. 1996) and thus the mortality rate can amount to approximately 1 percent (Vantrappen et al. 1993). It should therefore be performed by experienced endoscopists and, when possible, in an elective manner. Before colonoscopy, rectal enemas should be applied with caution, in order to maximize visibility and reduce the need for endoscopic manipulations, which can traumatize the already vulnerable colonic wall. Performing such interventions acutely, when the appropriate conditions are not met (inexperienced endoscopist working the shift alone, no previous rectal enema, lacking of necessary equipment in the emergency situation etc.) could increase the risk of complications for the already compromised patient.

Percutaneous endoscopic colostomy (PEC) is also increasingly proposed as an alternative to surgical treatment for Ogilvie’s syndrome. The advantages of this option are avoidance of general anesthesia and also that it allows for an appraisal of ischemia of the colonic wall through direct inspection. When the proper position is identified through diaphanoscopy, a needle is inserted through the skin in the lumen and a wire is positioned through the needle. The wire is then retrieved endoscopically and pulled through the aboral segments of the colon and transanally. The PEC-tube is then fastened on the wire and pulled again blindly through the colon, up to the needle position and then through the skin after an initial dilatation of the canal. There, it can be fixed similar to a percutaneous endoscopic gastrostomy (PEG). This method also allows for a colonic irrigation through the placed tube afterwards. Additionally, it can be easily removed once the colonic function recovers. PEC is proposed as safe and effective in the hands of experienced endoscopists (Lynch et al. 2006).

It is, however, associated with a complication rate of approximately 42 percent, including wound infection, bleeding or hematoma formation, granuloma and retraction of the PEC, as well as perforation leading to peritonitis in up to 14% of cases, among others (Bertolini et al. 2007). Bertolini also concluded that the relatively high incidence of immediate and delayed serious complications (≥ 5 percent) after PEC placement emphasizes the need to obtain fully informed consent, and to provide adequate care after the procedure. Keeping in mind the aforementioned rate of complications, a PEC placement could be reserved for patients who are too ill to operate, when other medicinal or endoscopic approaches have failed.

In our patient sample, 14 patients (17%) had had unsuccessful treatment with endoscopic therapy before surgery. Two patients (2.4%) were operated as emergency case after colonic perforation during/shortly after endoscopic decompression. This corresponds to the current literature and points to the necessity that such procedures should be performed by expert endoscopists. One reason for the low number of patients treated endoscopically was rapid clinical deterioration under conservative/pharmacological therapy, necessitating an emergency surgery.

Step-3: Surgical therapy as a last resort

Surgical therapy has been to date reserved for patients unresponsive to maximum conservative, pharmacological or endoscopic forms of treatment, or those who develop severe complications, such as critical colonic ischemia or perforation. Surgical therapy is associated with a high morbidity and mortality rate, varying between 30 and 60 percent (De Giorgio and Knowles 2009, Vanek et al. 1986), much higher than those for patients with Ogilvie's syndrome who eventually manage to avoid a surgical intervention. This is most probably a reflection of the severity of the patients' underlying medical condition, as the majority of those undergoing surgery are generally the more complicated ones, with numerous comorbidities and organ dysfunctions at the time when surgery is indicated. It must also be stressed that patients eventually undergoing surgical intervention, have progressed to maximal colonic dilatation unaffected by

preceding therapies and some of these patients present with bacterial translocation and sepsis through ischemic or perforated colon (Saunders and Kimmey 2005).

The data of our series confirm this evidence base. Mortality after emergency surgery for Ogilvie's syndrome ranges between 30 and 60%, depending on co-morbidities, delayed treatment and presence of ischemia or perforation (De Giorgio and Knowles 2009, Wells et al. 2017). In our series, it must be kept in mind that 10% of patients were classified as ASA 5 at the time of surgery, which also contributed to the high mortality rate of 54%.

Such operations are usually performed in an emergency manner. The type of procedure is usually decided according to the intraoperative findings. These can vary between normal looking -though dilated- colon, to ischemic changes and edema, to imminent or occurred perforation. The affected colonic segment is usually resected and an enterostomy with a Hartmann´s stump or mucous fistula are performed. A primary anastomosis is best avoided when treating such multimorbid and often septic patients, requiring heavy fluid replenishment and catecholamine support (Maloney and Vargas 2005). The healing process is often compromised because of sepsis, volume loading and vasoconstriction in the visceral arteries through a high continuous catecholamine administration.

Surgical morbidity in our series was 62.2%, which is similar to the known literature. Although we did not identify any studies reporting on morbidity, a documented mortality of 30-60%, as mentioned above, leads us to the conclusion that morbidity could easily exceed 60% in the series with the highest mortality rates (De Giorgio and Knowles 2009, Wells et al. 2017). Especially re-operations for bleeding and insufficiency of Hartmann's stump were common complications.

Regarding the intra-operative choice of surgical extent, the distribution of types of surgery (cecostomy and right hemicolectomy vs. subtotal colectomy) correspond to the extent of bowel dilatation. Additional to that decision variable, the use of indocyanine green (ICG) fluorescence has become frequent in our current practice to assess the extent of ischemia within dilatated colonic segments. Using ICG intraoperatively, the surgeon can estimate the area of the colon which is affected or ischemic and

consequently better determine the resection margins required, in order to ensure there is no insufficiently perfused colon left behind, which could lead to a further septic deterioration of the patient (Karampinis et al. 2018). The fluorescent angiography can then be evaluated shortly thereafter, using an appropriate device e.g., PinPoint or SPY Elite (Novadaq, Canada) and help provide additional information which may lead to a bowel sparing surgical approach (Figure 13).

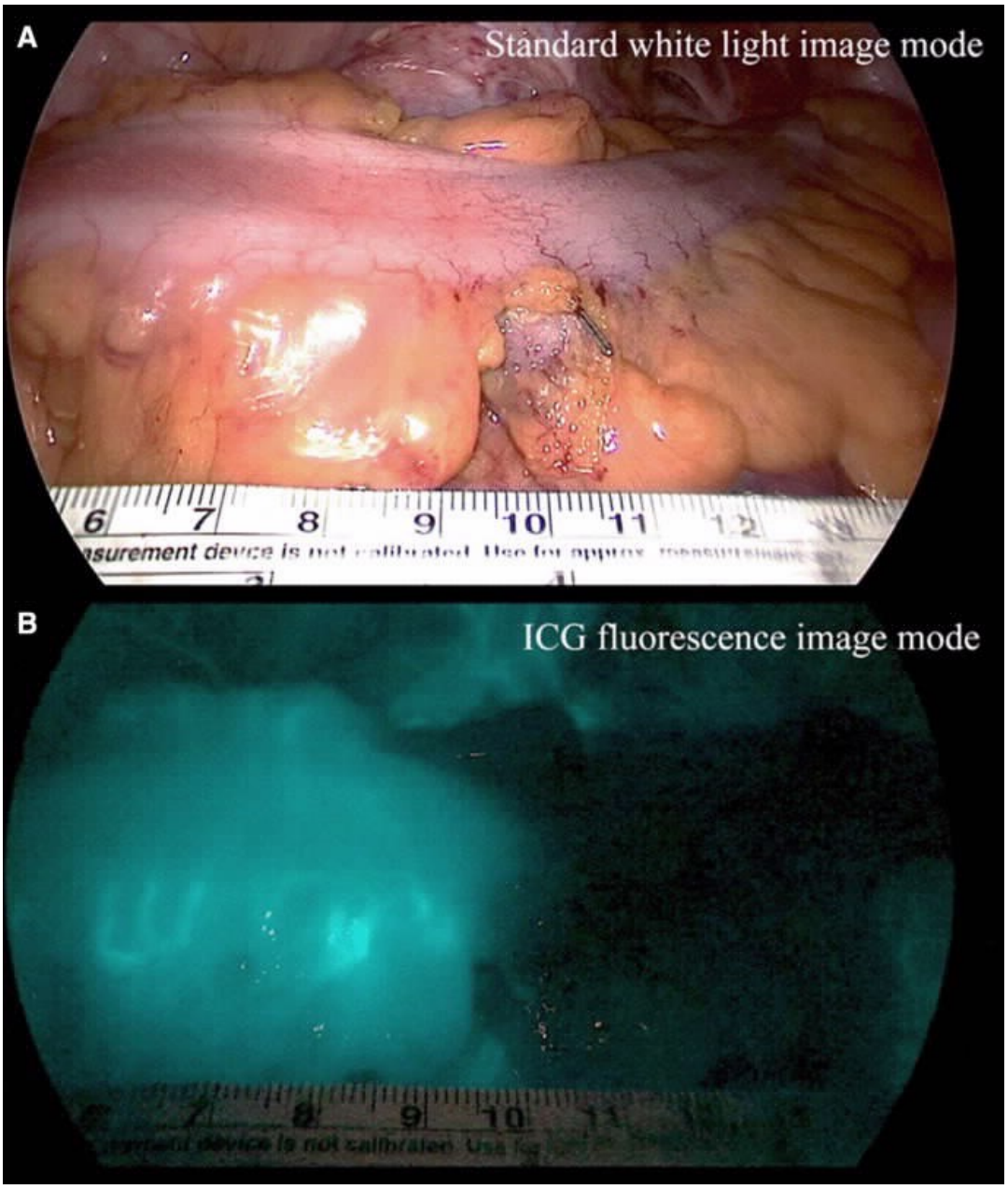

Figure 13. A: standard macroscopic view of the colon. B: real-time fluorescent angiography after ICG administration. Source: Son 2018. doi: 10.1007/s00464-018-6439-y

In the rare occasion, where the colon is simply dilated but the colonic wall does not seem compromised, a cecostomy can be performed. Cecostomy, with or without

antegrade lavage, provides a quick and effective decompression of the colon when ischemia or infarction are excluded. Intraoperative ICG-fluorescence can provide useful in such situations, revealing possibly ischemic parts of the colon which are not yet visible to the surgeon's eye. Cecostomies, however, have some limitations. A thick abdominal wall might prove a challenge, when attempting to partially pull the cecum through it. The cecum itself might be too vulnerable to be pulled through and too much tension in the fixating suture can lead to dehiscence and retraction of the ostomy. A simple dehiscence or a partial retraction could be treated conservatively. A complete retraction, however, necessitates an emergency revision operation, since stool can leak through the opened cecum in the abdominal cavity.

Our series contained five patients with cecostomies. Markedly, the ostomy complication rate was very high (40%), contributing to the very high rate of revisional surgery of 80%. This corresponds to the current literature with 37.5 - 50% (Lynch et al. 2006, Benacci et al. 1995, Bertolini et al. 2007, Ramage et al. 2003) and is mainly explained by the fact that the most instable patients frequently receive this surgical option so as to avoid more aggressive and longer surgical procedures.

Our series

Summarizing the series presented hereby, the mortality rate for operated patients during the same hospital stay was almost 54 percent. The patients in this study came exclusively from an intensive care unit setting, featuring a wide range of co-morbidities and multi-organ failure at the time of operation. All of the patients were operated in an urgent manner. Most of those patients also presented with postoperative complications, for which one or more consecutive operations had to be performed. In total 61 percent of the patients had to undergo revisional surgery, either due to complications, or in the context of a second look operation.

In the group of patients receiving a right hemicolectomy, 27.5% were later diagnosed with sepsis and/or intraabdominal abscess and had to be re-operated, whereas the frequency in the group receiving a subtotal colectomy was shown to be 21.6% (overall 23.2%). Regarding the postoperative hemorrhage, the frequencies were 7.5% and

13.5% respectively (overall 9.8%). In both groups the percentage of patients undergoing one or more revisions was quite similar (60% vs. 59.5%, overall 60.1%). Lastly, none of the patients in the first group was diagnosed with an insufficiency of Hartmann's stump, whereas in the second group the frequency amounted to 5.4% (overall 2.4%). Of the 5 patients who received a cecostomy, 4 (80%) had to be operated again, 2 (40%) experienced an ostomy complication, 1 (20%) developed an intraabdominal abscess, while none suffered a postoperative hemorrhage.
This risk and complication profile consolidates existing literature and earlier series of surgical therapy (Wells et al. 2017, De Giorgio and Knowles 2009).

The most important prognostic factors, which were significantly associated with a higher mortality rate were ASA score, necessity for continuous catecholamine support and already established mechanical ventilation at the time of indication for surgery. The main factor associated with a smaller survival chance in the postoperative course was occurrence of postoperative bleeding, necessitating blood transfusion or revision operations. This points to the importance of general prevention, risk-tailored screening and early detection of Ogilvie's syndrome to maximize the chance of non-surgical management and survival.

Strengths and limitations of the study

Strengths: This study is - to our knowledge - one of the biggest series concerning surgical therapy and outcome of patients with Ogilvie's syndrome, involving a detailed and complete population in a specified time frame and thus limiting the natural heterogeneity of those patients and colonic conditions. The recruitment of those patients was made after thoroughly reviewing all OR-reports and imaging studies, to ensure that only the patients with the clinical/radiological diagnosis of Ogilvie's syndrome were selected. This allowed us to reduce the otherwise large heterogeneity of Ogilvie's syndrome cases and definitions within existing historical series.

Limitations: The study was monocentric and based for the biggest part on a retrospective case selection and exploratory data analysis. Relevant selection bias can therefore not be excluded. However, a clear and consistent case definition of Ogilvie's

syndrome was thoroughly verified in each case. Furthermore, prospective consecutive case screening and recruitment were added to increase patient sample size and robustness of data.

Conclusion and outreach

It is evident that, once surgical therapy is indicated and performed, the mortality rate is high. This is also due to the fact that, by the time of the surgical approach, the already multi-morbid patients have begun to develop severe complications, such as organ failures, due to peritonitis and sepsis following ischemia of the colonic wall and/or perforation and, thus, surgery is usually performed in an emergency manner. The data shown here may, therefore, be interpreted in two directions: the high rate of futile operations suggests that maximal conservative, pharmacological and early endoscopic decompression therapy should be preferred, in order to avoid the surgical trauma in these already critical patients. On the other hand, our data point to the necessity of earlier, more pro-active consideration of surgical therapy once a step-up approach of conservative management and endoscopic decompression have failed. Moreover, emphasis should be laid on systematic prophylaxis and early detection of Ogilvie's syndrome in high-risk patients before colonic wall perfusion and clinical deterioration become irreversible. Related research projects in our clinic are therefore focusing on preventive and diagnostic algorithms as well as biomarkers for intestinal ischemia in surgical ICU-patients (Schoettler et al. 2021).

5 SUMMARY

Ogilvie's syndrome, defined as acute colonic obstruction without mechanical cause, is a rare but serious clinical condition affecting mostly multi-morbid patients being treated in intensive care units. Current management guidelines describe a step-up approach of conservative, pharmacological and endoscopic therapy. Surgical treatment has traditionally been the last resort for critical patients with colonic ischemia or perforation. The evidence base for clinical outcome after surgical treatment of Ogilvie's syndrome is therefore scarce.

The purpose of this monocentric retrospective and prospective observational study was to evaluate the outcome of patients after surgical treatment for acute colonic pseudo-obstruction in a tertiary referral centre. Eighty-two patients were identified (58 males, 24 females, median age 62.3 years). The median amount of time between diagnosis and operation was 8 hours. Median cecum diameter was 10cm. Types of surgery included cecostomy (6.1%), hemicolectomy (48.8%) and subtotal colectomy (45.1%). Seventeen percent of the patients had a perforated colon while 29.2% showed peritonitis at the time of operation. Overall morbidity was 62.2% (2.4% insufficiency of the Hartmann´s stump, 15.9% ostomy complications, 23.2% sepsis/abscess formation, and 9.8% postoperative haemorrhage). Mortality was 53.7%, with a median of 6 days from first operation to time of death.

The data revealed a statistically highly significant association between increased mortality amongst patients with organ failure, as well as those with a worse American Society of Anaesthesiologists score at the time of operation. In this population, the association between other factors, such as sex, colonic diameter, extracorporeal membrane oxygenation therapy or type of surgical operation and mortality was not statistically significant.

Early detection by means of clinical symptoms and radiological findings are precondition for successful non-surgical management. The initial conservative management includes the placement of a nasogastric tube, treating of the underlying condition, discontinuing of drugs impairing gut motility, replenishing of fluids and monitoring of electrolytes. Drugs improving gut motility, such as neostigmine and

erythromycin should also be administered early on and can demonstrate a high success rate. When symptoms persist, endoscopic decompression with placement of a decompression tube is indicated and should be performed cautiously by an expert endoscopist. In cases of recurrence or long-persisting symptoms, a percutaneous endoscopic colostomy can be considered, while bearing in mind the high rate of complications involved with said intervention.

The surgical approach should be reserved for cases where every other therapeutic option has failed, and is associated with a high mortality rate. This finding has been corroborated by our data. The high morbidity and mortality of surgical therapy point to the necessity of avoiding surgery whenever possible. On the other hand, our data indicate that early, proactive consideration of surgical therapy may be key to improve outcomes once conservative management and endoscopic decompression are unsuccessful. Finally, emphasis should be laid on systematic prophylaxis and early detection of Ogilvie’s syndrome in high-risk patients before colonic wall perfusion and clinical deterioration become evident and irreversible.

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7 IMAGE SOURCES

Fig. 1
Wikimedia: Organization of the gastrointestinal tract. Obtained 13.08.2021 https://upload.wikimedia.org/wikipedia/commons/f/fb/GI_Organization.svg

Fig. 2
Musculoskeletal Key: neurogenic bowel dysfunction and rehabilitation. Obtained 13.08.2021 https://musculoskeletalkey.com/neurogenic-bowel-dysfunction-and-rehabilitation

Fig. 3
HyperPhysics © 2016 Georgia State University: Tension in Arterial Walls. Obtained 13.08.2021 http://hyperphysics.phy-astr.gsu.edu/hbase/ptens3.html

Fig. 4a
Brown Emergency Medicine blogspot: POCUS for Appendicitis. Obtained 13.08.2021 http://brownemblog.com/blog-1/2017/3/3/pocus-for-appendicitis

Fig. 4b
Ultrasound Cases: Obstruction and Ileus. Obtained 13.08.2021 https://www.ultrasoundcases.info/obstruction-and-ileus-4241/

Fig. 5
Jaffe T, Thompson WM. Large-Bowel Obstruction in the Adult: Classic Radiographic and CT Findings, Etiology, and Mimics. Radiology 2015; 275: 3, 651-663. https://pubs.rsna.org/doi/full/10.1148/radiol.2015140916

Fig. 6
Radiopaedia.org. Obtained 13.08.2021. https://radiopaedia.org/cases/11684/studies/32135?lang=us

Fig. 7 (left)
Thieme-Connect. Obtained 13.08.2021 https://www.thieme-connect.de/products/ebooks/lookinside/10.1055/b-0034-59905

Fig. 7 (right)
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Fig. 8

Ni X, Fan S, Zhang Y, et al. Coordinated Hospital-Home Fecal Microbiota Transplantation via Percutaneous Endoscopic Cecostomy for Recurrent Steroid-Dependent Ulcerative Colitis. Gut Liver. 2016; 10(6): 975-980.

Fig. 9-12

Electronic clinical record database of the University Medical Centre Mannheim

Fig. 13

Son GM, Kwon MS, Kim Y, Kim J, Kim SH, Lee JW. Quantitative analysis of colon perfusion pattern using indocyanine green (ICG) angiography in laparoscopic colorectal surgery. Surg Endosc. 2019; 33(5): 1640-1649.

8 CURRICULUM VITAE

PERSONAL DATA

Name:	Tzatzarakis Emmanouil
Date of birth:	26.07.1990
Place of birth:	Trikala, Greece
Marital status:	married, 1 son
Father:	Tzatzarakis Antonios
Mother:	Mpalani Eleni

SCHOOL CAREER

2002 – 2005	Middle school (Gymnasium), 8. Gymnasion Trikala
2005 – 2008	High school (Lyceum), 4. Lykeion Trikala with graduation Apolyterium (equivalent to german Abitur)

UNIVERSITY CAREER

09/2008 – 08/2014	Medical school, Kapodistrian University of Athens, Greece
2010 – 2014	Scholarship of the Kapodistrian University of Athens
08/2013 – 06/2014	Practical year (pediatrics, general surgery, internal medicine, obstetrics/gynecology)
08/2014	Medical degree with an excellent score
08/2014	Medical license in Greece
01/2015	Medical license in Germany
04/2015 to 06/2021	Resident in general surgery, Universitätsmedizin Mannheim
06/2021	German Board certification in General Surgery
Since 06/2021	Specialist registrar for general surgery, Universitätsmedizin Mannheim

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