Use of Hugo™ RAS in General Surgery: The First 70 Cases at a German Centre and a Systematic Review of the Literature

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Abstract: Introduction: The versatile open modular design of the newly introduced robotic platform Hugo™ RAS is expected to allow its rapid spread in general surgery. However, the system is not yet approved for use in oesophageal and HPB-surgery and is not licensed worldwide. The aim of this work was to review the current spectrum of general surgical procedures that may be feasibility and safely performed with Hugo. Methods: We retrospectively reviewed our own series and performed a systematic review of all the published reports of general surgical procedures performed with this system in the literature. Results: Seventy patients underwent general surgery with Hugo at our institution, and another 99 patients were reported in the literature. The most common procedures were colorectal (n = 55); cholecystectomy (n = 44); repair of groin, ventral and hiatal hernias (n = 34); upper GI (n = 28); adrenalectomy (n = 6); and spleen cyst deroofing (n = 2). No device-related complications were reported. Arm collisions and technical problems were rare. The docking and console times improved in all series. The port positions and robotic arm configurations varied among authors and depended on the surgical indication, patient characteristics and surgeon’s preference. Conclusions: A wide spectrum of general surgical procedures has been safely and effectively performed with the Hugo RAS, even by robotically inexperienced teams with a limited choice of instruments. Technical improvements to the system and the introduction of robotic energy devices may help Hugo evolve to a vital alternative to established robotic systems.

Keywords: robot-assisted; Hugo; general surgery; setup

1. Introduction

The Hugo™ robotic-assisted surgery (RAS) (Medtronic, Dublin, Ireland) platform is one of several much-awaited alternatives to the DaVinci robot. It consists of a system tower; an open console, including a widescreen HD-3D display with dedicated glasses, two pistol-like handgrips as arm-controllers and a footswitch panel; and four individual arm carts with a wide manoeuvre range. The platform was first introduced in South America and the Asia–Pacific region and later became commercially available in other parts of the world. In the USA, the platform is still an investigational device that is not for sale and avoids FDA approval. Reports on the clinical use of Hugo first began appearing after the device had received its CE mark in the EU for use in gynaecologic and urologic surgery in October 2021 and for general surgery a year later. So far, about 60 Hugo™ RAS devices have been installed in Europe alone, showing promising results for prostatectomy, nephrectomy and hysterectomy [1–3]. It is believed that the open modular design of the platform would also allow its rapid adoption in general surgery. However, due to its novelty, the limited choice of instruments, setup guides that are under development and its missing certification in some parts of the world, published experience with Hugo-assisted general surgical procedures has been very limited.

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This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).
The aim of this study was to summarize the current experience with Hugo RAS in general surgery with a focus on the spectrum of indications, feasibility and safety of the procedures and technical features of the system through a systematic review of the existing literature along with our own early insights from the first 70 cases with this platform.

2. Materials and Methods

2.1. Own Patients

A retrospective chart review was performed of all patients who underwent robotic-assisted general surgical procedures at our hospital after beginning work with the Hugo RAS in February 2023 until 31 May 2024. Due to regulatory issues in Germany, no procedures were performed between April and October 2023, so that the study period of active use of Hugo was 9 months. No specific exclusion criteria were applied for patient selection. All patients gave written informed consent for robotic surgery and were personally informed by the operating surgeon about the procedure in all its aspects, including its novelty and the limited experience with that system. They signed a special informed consent form including additional remarks about possible device failures and device-induced complications. This observational study was approved by the Ethics Committee of Ruhr University Bochum (No. 23-7872-BR). It was conducted in accordance with the Declaration of Helsinki. In addition to clinical perioperative parameters, exact data on trocar positioning, docking and console times and the technical performance of the device were gathered. All surgeries were recorded by the DS1 system of the platform and were reviewed via the Touch Surgery™ 7.36 (Digital Surgery Ltd., London, UK) application. The docking time was defined as the time needed to attach all the manipulator arms to the instruments and to test them after trocar placement. The console time was the time between docking and final undocking. The total operative time was defined as the time from skin incision until skin closure.

Our surgical team had previous extensive experience with open and laparoscopic surgeries but no clinical experience with robotic surgery. Extensive theoretical and practical training offered by the vendor was completed as already mentioned in a previous report by us [4]. The system components of the Hugo RAS platform have been repeatedly described in detail elsewhere [5–7].

2.2. Systematic Review of the Literature

As no MeSH terms for Hugo RAS have been established, two of the authors (OB and TF) performed an independent initial search in PubMed, Web of Science and Google Scholar with the exact text phrases “Hugo RAS”, “Hugo Medtronic” and “Hugo robotic surgery” to identify relevant records. All reports on Hugo RAS published until 31 May 2024, were screened, including an additional manual check of their reference lists, and those reports describing the clinical use of the platform in general surgery were retrieved in full-text and included in the summary. Publications in the fields of gynaecologic and urologic surgery, as well as those reporting duplicate or no patient results were excluded. Final records to be included were checked by all four authors of the review—disagreements and missing data were resolved by personally contacting the authors of the original studies and analysing the raw data when necessary. As all included studies were of the lowest evidence level, being retrospective case reports and low-volume series of strongly selected cases, no formal bias risk assessment was performed. Selection, attrition, performance, detection and reporting bias were characteristic for all selected records. The PRISMA flow diagram of the systematic review is presented in Figure 1. This systematic review is registered in PROSPERO (No. CRD42024558581).
Figure 1. PRISMA diagram of the systematic review of the literature March 2022–May 2024.

3. Results
3.1. Own Patients and Procedures

The first two robotic-assisted general surgical procedures with the Hugo™ RAS at our centre included a cholecystectomy and a sigmoidectomy, performed on 13 February 2023. They, at the same time, represented the first-in-human procedures with the Hugo™ RAS in Germany. Since then, a variety of general surgical procedures have been performed in 70 patients. A summary of our initial experience with the Hugo RAS is presented in Table 1. Along with the listed 31 colorectal surgeries, a wide variety of concomitant procedures were performed, such as appendectomy, adhesiolysis, adnexectomy, fundoplication and rectopexy. There was no mortality in the group. All non-colorectal procedures were uneventful. Complications occurred only after major colorectal surgery: two presacral haematomas after rectosigmoid resections were treated via CT-guided drainage, and an anastomotic tear after an ultralow rectal resection was treated with endoluminal negative pressure. A high output stoma after another low anterior resection resulted in transient renal failure and had to be closed. An elderly patient received antibiotic treatment for a clostridial infection after a right hemicolectomy. Another one suffered a postoperative paralytic ileus, resulting in a prolonged hospital stay.

Table 1. The first 70 general surgical procedures with Hugo™ RAS at our centre over a period of 9 months.

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</thead>
<tbody>
<tr>
<td>Cholecystectomy</td>
<td>Lithiasis</td>
<td>32 (23 F/9 M)</td>
<td>62 (16–86)</td>
<td>28 (19–35)</td>
<td>10 (3–15)</td>
<td>45 (21–172)</td>
<td>72 (57–182)</td>
<td>0/0</td>
<td>2 (1–5)</td>
</tr>
<tr>
<td>Sigmoidectomy</td>
<td>Diverticula</td>
<td>11 (6 F/5 M)</td>
<td>66 (52–77)</td>
<td>25 (21–37)</td>
<td>10 (7–18)</td>
<td>120 (70–183)</td>
<td>189 (115–249)</td>
<td>0/1</td>
<td>7 (5–12)</td>
</tr>
<tr>
<td>Rectum resection</td>
<td>Cancer</td>
<td>8 (2 F/6 M)</td>
<td>66 (41–85)</td>
<td>27 (21–34)</td>
<td>12 (7–15)</td>
<td>233 (120–332)</td>
<td>325 (290–420)</td>
<td>2/2</td>
<td>10 (7–34)</td>
</tr>
<tr>
<td>Right colectomy</td>
<td>Cancer</td>
<td>8 (5 F/3 M)</td>
<td>67 (61–87)</td>
<td>27 (21–30)</td>
<td>12 (10–15)</td>
<td>180 (85–316)</td>
<td>219 (193–280)</td>
<td>1/1</td>
<td>7 (6–14)</td>
</tr>
<tr>
<td>Hiatal hernia</td>
<td>Hiatal hernia</td>
<td>3 (2 F/1 M)</td>
<td>47 (24–51)</td>
<td>27 (21–36)</td>
<td>10 (6–12)</td>
<td>151 (120–169)</td>
<td>197 (163–211)</td>
<td>0/0</td>
<td>6 (5–7)</td>
</tr>
<tr>
<td>Hartmann reversal</td>
<td>Colostomy</td>
<td>2 (1 F/1 M)</td>
<td>50 (33–67)</td>
<td>27 (24–30)</td>
<td>13 (12–14)</td>
<td>142 (120–164)</td>
<td>278 (264–290)</td>
<td>0/0</td>
<td>7 (7–7)</td>
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<tr>
<td>Gastric resection</td>
<td>Schwan-noma</td>
<td>1 (M)</td>
<td>68</td>
<td>26</td>
<td>13</td>
<td>115</td>
<td>147</td>
<td>0/0 5</td>
<td></td>
</tr>
<tr>
<td>Adrenalectomy</td>
<td>Adenoma</td>
<td>1 (F)</td>
<td>69</td>
<td>19</td>
<td>12</td>
<td>150</td>
<td>200</td>
<td>0/0 6</td>
<td></td>
</tr>
<tr>
<td>Rectum extirpation</td>
<td>Cancer</td>
<td>1 (F)</td>
<td>65</td>
<td>30</td>
<td>15</td>
<td>240</td>
<td>360</td>
<td>0/0 13</td>
<td></td>
</tr>
<tr>
<td>Left colectomy</td>
<td>Cancer</td>
<td>1 (M)</td>
<td>68</td>
<td>23</td>
<td>12</td>
<td>155</td>
<td>228</td>
<td>0/0 6</td>
<td></td>
</tr>
<tr>
<td>Cyst deroofing</td>
<td>Splenic cyst</td>
<td>2 (1 F/ 1 M)</td>
<td>55 (44–66)</td>
<td>38 (36–40)</td>
<td>15 (13–17)</td>
<td>90 (81–100)</td>
<td>130 (117–143)</td>
<td>0/0 3 (3–3)</td>
<td></td>
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</tbody>
</table>

For single cases, actual values are shown; for multiple cases, median values with (minimum–maximum) range are shown. F—female; M—male.

3.2. Patients and Procedures Reported in the Literature

The earliest report on the use of Hugo in abdominal non-gynaecologic and non-urologic surgery was published online by the Italian team of Raffaelli et al. in 2022, who described five transabdominal adrenalectomies [5]. In early 2023, the first three cases of partial colectomy were described by Bianchi et al. [6]. Currently, a total of 18 original papers by 11 different teams have been published, most of them coming from Italy (n = 7) and Spain (n = 4). A summary of these is presented in Table 2 [4–21].

Table 2. A summary of published data on general surgery with Hugo™RAS in chronological order until 31 May 2024.
3.3. Combined Data on Most Common Surgical Procedures

3.3.1. Lower GI surgery

Following the first original case series of colectomies by Bianchi et al., several other authors reported the feasibility and safety of colorectal procedures with Hugo [6]. Romero-Marcos et al. published their experience including six rectal resections, three sigmoidectomies and a rectopexy [17]. Gangemi et al. reported a mixed series of patients who underwent various procedures, including five ileocecal resections, a right hemicolecotomy and a sigmoidectomy [7]. Caputo reported recently on three rectal resections using different setups [16]. Our experience with Hugo includes 31 colorectal procedures, most of them being sigmoid resections (n = 11), rectal resections (n = 8) and right hemicolecotomies (n = 8). A left hemicolecotomy, an APR and two Hartmann's reversals were also performed. A wide variety of setup configurations were used by different authors; however, similar operating times and clinical results were reported among all series. The butterfly 2 × 2 and the 3 × 1 configurations were the most commonly used, and the compact setup with the camera arm between the legs was preferred for low rectal resections (Figure 2).
Order of arm placement
A docked first | D docked last

A
Surgeon Left Hand
Angle 30°
Tilt – 15°

B
4th Arm (optional)
Angle 140°
Tilt – 30°

C
Surgeon Right Hand
Angle 250°
Tilt + 30°

D
Endoscope
Angle 90°
Tilt – 30°

Nurse
Assistant
Anaesthesia

vascular control and colon mobilisation
Figure 2. (A) Lower GI setup for vascular control and colon mobilisation. (B) Lower GI setup for pelvic mobilisation and anastomosis.

3.3.2. Upper GI surgery

The most common upper GI procedure was bariatric Roux-Y gastric bypass (n = 15), followed by a case series of 10 Heller myotomies for achalasia [12,15]. After publishing their initial results with RYGB in four patients, Raffaelli et al. reported later on a larger series of 15 morbidly obese patients treated with the use of Hugo [12]. Only the second report was included in this systematic review. Additionally, a sleeve resection and a subtotal gastrectomy were reported [7]. We performed a wedge gastric resection for a large benign tumour of the stomach. The setup for procedures in the upper abdomen is well established and widely accepted, making them feasible and safe (Figure 3).
3.3.3. Cholecystectomy

Most publications on Hugo-cholecystectomy came from centres in Italy and Spain, reporting relatively small case series of up to seven patients. The largest reported single-centre study provided technical details and setup modifications for the procedure in 14 consecutive cases—it was published by our team in 2023 [4]. Meanwhile, we have performed 32 CCEs with excellent clinical results and no technical problems. A variety of trocar and robotic arm positionings for CCE were proposed by other authors [7,9,14].

3.3.4. Hernia Repair

There are five reports solely focused on the repair of abdominal wall hernia with Hugo. Mintz et al. reported on the successful rTAPP of 13 groin hernia repairs in 10 patients [10]. Quezada et al. performed transversus abdominis release in 10 patients with large ventral hernias using redocking for each side [20]. The short shaft of Hugo’s instruments was pointed out by the authors as the main limitation. Jebakumar et al. described in detail the use of Hugo for two cases of rTAPP and five cases of ventral hernia repair in the IPOM technique [13]. Three robotic arms were used by all authors in cases of abdominal wall repair. Hiatal hernia repair as a separate procedure or as a part of fundoplication were described by Gangemi and Quijano in two cases [7,8]. We also performed three repairs of hiatal hernia: two of them with mesh reinforcement, and the third one combined with a Toupet fundoplication. In all cases of hiatal hernioplasty, four robotic arms in an upper abdominal setup were used. We do not perform the robotic repair of abdominal
wall hernia because in Germany, this type of surgery is increasingly pushed into the strongly underfinanced outpatient care.

3.3.5. Adrenals and Spleen

A case series of three left and two right adrenalectomies was published earlier by Raffaelli et al., using a three-arm setup and an assistant port in the periumbilical region [5]. We confirmed that a left adrenalectomy using a similar subcostal triangular positioning of the robotic trocars is safe and feasible; however, we placed the assistant trocar between the camera and right-hand trocars in the left lower abdomen. The Italian colleagues positioned all three arms at the same ipsilateral side of the patient, whereas we distributed two arms on the left side and one arm on the other side of the patient to avoid collisions and provide more freedom for the assistant. All cases were performed in a lateral decubitus position. The same setup but with four robotic arms and an assistant trocar was successfully applied by our team to perform the deroofing of large symptomatic spleen cysts in two very obese patients.

3.3.6. Technical Performance of Device

We experienced one technical problem with the device in the beginning of this series. In patient No. 3, one of the arms repeatedly did not recognize the instruments. The system had to be restarted twice until function was regained. The arm was successfully repaired before the next procedure. Also, a software update was necessary after the fifth procedure to eliminate some bugs. These technical problems led to a time delay but no adverse clinical events. Subtle arm collisions were repeatedly detected but tolerated by the device and did not interrupt the proper functioning of the system. Neither the instruments nor the other hardware parts broke or showed defects. There were no problems with the image or video transfer. All procedures are saved in the cloud and are easy to review at any time using the Touch Surgery™ application on any device, allowing notifications, workflow analysis and video editing. There were no device-related patient injuries, neither in our collective nor in the literature.

4. Discussion

This paper offers a summary of all the available reported cases of general surgical procedures performed with the help of the Hugo RAS robotic platform so far.

As expected, since its introduction, the platform has mostly been used in the fields of urology and gynaecology. The noninferiority of Hugo RAS compared to DaVinci was already demonstrated in some large series of prostatectomies and nephrectomies [22,23]. The expectations of its successful use in general surgery are based on its open modular design allowing improved communication within the surgical team and the flexibility in the configuration of the four individual arms. The ergonomic position of the console for the surgeon, the pistol-like grips resembling laparoscopic ones and the lower price have been discussed as further possible advantages of Hugo [4–7]. The novelty of the device is inherently associated with some temporary disadvantages, such as the limited choice of instruments, lack of worldwide certification and approval for some major surgical procedures, immature training process, shortage of experienced proctors and difficulties in product supply.

The summary of our own initial experience and the review of the literature revealed that despite the abovementioned limitations, a wide spectrum of procedures in general surgery are feasible and safe to perform using the Hugo RAS. Interestingly, the clinical results and operating times of surgical teams without previous robotic experience, such as ours or that of Romero-Marcos, did not differ from those of robotically experienced authors. This paradox indicates that either Hugo RAS and DaVinci are quite different in terms of handling or that the learning curve with Hugo is steep and its interface extremely
user-friendly. Moreover, our data provide evidence that general surgery with this system may be safe and feasible even in non-selected patient populations.

Indications for Hugo use showed geographical differences. Thus, reports on hernia repair came predominantly from countries outside Europe, just opposite to a series of colorectal resections and cholecystectomy. Such contrasts may reflect differences in health care reimbursement policies around the world. In Germany, current governmental attempts focus on redirecting all hernia repair into the underfinanced outpatient sector, which makes the use of robotic platforms for this indication unattractive. Another point is the strict hygiene regulation in the EU, which has rated the resterilisation of Hugo instruments insufficient and prohibited their multiple use so far.

On an international level, Hugo was most often used for colorectal surgery. The specific challenges of these procedures include a wide multi-quadrant surgical field, extending from the mid/upper abdomen to the lower abdomen and pelvic region, and the use of multiple different instruments for the resection and reconstruction steps of the operation. The modular design of Hugo with four independent arms may offer an advantage to the single pivot point design of the DaVinci system; however, it lacks automatic targeting and procedural setup-memory. Thus, the manual setting of the docking and tilt angles is needed in every single patient, which may be challenging and requires profound device-specific experience of the surgical team. According to our experience and the available literature, the modular design of Hugo cannot fully prevent redocking in complex procedures such as low anterior rectal resections. The major limitations of the Hugo platform with respect to colorectal surgery include the lack of a wristed robotic advanced energy device and some other instruments, such as a clip-applicator and a linear stapler. ICG fluorescence is still not available for the Storz camera of Hugo. The shaft of Hugo’s instruments is significantly shorter than those of DaVinci, which is a problem in tall patients and those with a larger abdominal cavity, especially in multi-quadrant surgical procedures such as colorectal ones or the repair of large ventral hernias. A comparison of the features between the Hugo RAS and DaVinci platforms is summarized in Table 3.

Table 3. Comparison of the major features of the Hugo and DaVinci robotic platforms.

<table>
<thead>
<tr>
<th>Features</th>
<th>Hugo RAS</th>
<th>DaVinci</th>
</tr>
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<tbody>
<tr>
<td>Platform design</td>
<td>Modular with 4 independent arms</td>
<td>Single pivot tower</td>
</tr>
<tr>
<td>Ergonomics of surgeon console</td>
<td>Free head and neck movement</td>
<td>Constant head and neck strain</td>
</tr>
<tr>
<td>Team communication</td>
<td>Direct and easy through open design</td>
<td>Limited, no eye contact to rest of team</td>
</tr>
<tr>
<td>Hand controls</td>
<td>Laparoscopy-like pistol grips</td>
<td>Endo-wrist finger grips</td>
</tr>
<tr>
<td>Resolution and image quality</td>
<td>Excellent via dedicated 3D-glasses</td>
<td>Excellent via console binoculars</td>
</tr>
<tr>
<td>Side observers</td>
<td>3D-glasses allow multiple observers</td>
<td>Dual console allows a single 3D-observer</td>
</tr>
<tr>
<td>Teaching</td>
<td>Difficult due to single console</td>
<td>Easy due to dual console</td>
</tr>
<tr>
<td>Instruments</td>
<td>Short shaft, single use, limited choice</td>
<td>Great variety of instruments, multiple use</td>
</tr>
<tr>
<td>Setup configuration</td>
<td>Individual setup for every patient</td>
<td>Automatic setup after targeting</td>
</tr>
<tr>
<td>Docking memory</td>
<td>Not available</td>
<td>Yes, procedure specific</td>
</tr>
<tr>
<td>Vessel sealing device and linear stapler</td>
<td>Wristed and straight, not yet certified</td>
<td>Wristed, available</td>
</tr>
<tr>
<td>Camera</td>
<td>0° and 30°, 10 mm, no ICG</td>
<td>0° and 30°, 8 mm, ICG</td>
</tr>
<tr>
<td>Proctorship</td>
<td>Limited number of proctors</td>
<td>Plenty of experienced proctors</td>
</tr>
<tr>
<td>Training program</td>
<td>Short, basic, still in development</td>
<td>Established variety of courses</td>
</tr>
<tr>
<td>Role of bed-side assistant</td>
<td>Crucial, active</td>
<td>Supporting, passive</td>
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</table>
The limited portfolio of robotic instruments currently available for Hugo requires more active participation from the bed-side assistant, who must apply clips, staplers and vessel sealing through an additional laparoscopic port. Increased interaction between the console and bed-side surgeon is therefore of utmost importance, and this is enabled by the open design of the platform. As the four robotic arms are relatively bulky and possess a large volume of movement outside the body, the assistant sometimes suffers limited manoeuvrability and must be careful not to be squeezed between the arms.

Some minor but annoying shortcomings of the Hugo system include the current time limit of 45 min for the use of the monopolar shears and the need to restart the whole system after every single procedure. Attention should be given to positioning the surgical table as high as possible to allow an adequate volume of movement for the arms with a positive tilt—this may sometimes lead to a higher risk of contact between the long sterile robotic arms and the non-sterile parts attached to the ceiling such as the lamps or anaesthesia devices.

The initial lack of clinically proven setup guides has led to a variety of setup configurations being used by different authors for the same procedure. It was especially obvious in colorectal surgery, where the number and positioning of ports, the positioning of the arms and the number of redockings differed substantially among the authors. However, these differences appeared to not affect the docking times, duration of surgery or clinical outcomes, providing evidence that the modular design of Hugo may effectively allow a personalized setup considering both the individual patient’s characteristics and the surgeon’s preferences.

Despite its comprehensive character and detailed presentation of the current Hugo standards in general surgery, this systematic review suffers some major limitations. The most important flaw comes from the low evidence level of the included studies and their heterogeneity: 18 studies reported on less than 100 patients treated for a variety of diseases and retrospectively described the outcomes of a relatively broad spectrum of procedures. Furthermore, the lack of established setup guides, the preferences and individual robotic experience of surgeons and the selection bias made the reported results hardly comparable. Another drawback is the lack of a direct comparison of Hugo to DaVinci as the current gold standard in robotic surgery and to other newly introduced robotic platforms, especially in terms of cost effectiveness.

Adding our own experience with Hugo in 70 patients to the results of this systematic review aimed to show the feasibility and safety of this platform in general surgery and present a firsthand point of view of its advantages and limitations. However, this additional data cannot overcome the already mentioned drawbacks of the review regarding heterogeneity and the small patient numbers.

In conclusion, the Hugo RAS platform allowed a wide spectrum of abdominal surgical procedures to be safely performed. Ongoing technical development and software updates of the system are expected to improve its performance. To ensure a more rapid dissemination and the increasing use of the system in general surgery, joint international efforts including the creation of a procedural register and the establishment of standard clinically proven setup guides have to be endorsed.

**Author Contributions**: Conceptualization: O.B.; methodology: O.B. and T.F.; validation: O.B., T.F. and W.U.; formal analysis O.B., T.F. and I.S.; investigation: O.B. and T.F.; resources: O.B.; data curation: O.B., T.F. and I.S.; writing—original draft preparation: O.B.; writing—review and editing, T.F., I.S. and W.U.; visualization: O.B. and T.F.; supervision: W.U.; project administration: W.U. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patients to publish this paper.

Data Availability Statement: All raw data analysed in this article are available and saved on the data server of Katholisches Klinikum Bochum, and access may be requested at any time by addressing the Ethics Committee of Ruhr University Bochum.

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