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Research Article

The Application of PROMETHEE and K-means Clustering Techniques for Enhancing Robotic Assistance in Bariatric Surgery

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ABSTRACT

Robotic bariatric surgery (RBS) uses robotics in weight loss operations. The robotic system has been tremendous in the field of bariatric surgery (BS) owing to its overwhelming advantages. As a result, surgeons perform RBS by controlling robotic arms equipped with surgical equipment from a console. In this study, our focus is to evaluate the BS dataset and techniques such as Roux-en-Y gastric bypass (RYGB), laparoscopic vertical sleeve gastrectomy (LGSV), adjustable gastric band (AGB), mini gastric bypass (MGB), single anastomosis duodenal bypass (SADI-S), open RYGB, biliopancreatic diversion with duodenal switch (BPD-DS), and mini gastric bypass one anastomosis gastric bypass (MGB - OAGBP). We used the Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) and K-mean clustering analysis to look at how well RBS could help with surgery outcomes. Our result showed that the K-mean of 11 neurons input layer has 100 Self-Organizing Maps (SOM). Also, the PROMETHEE result showed that MGB-OAGBP ranked highest with 0.0056 as the net flow value. The integration of PROMETHEE net flow values, positive and negative outranking values, and BS predicted values demonstrated that MGB-OAGDP ranked highest. In conclusion, our study shows that PROMETHEE and K-means clustering can improve the efficiency of RBS, which can lead to better outcomes for patients.

1. INTRODUCTION

Bariatric surgery (BS) is a group of surgeries commonly employed for the improvement of weight loss through modifying the digestive tract's structure and physiology [1]. BS is also known as the most effective and long-lasting treatment option for morbid obesity [2], i.e. a group of procedures including gastric bypass used specifically in the surgical reduction of weight. It is typically recommended in an unsuccessful or when weight-related health concerns are severe. BS primarily helps patients lose a substantial amount of weight, which should improve their health and reduce the negative effects of obesity on their daily lives. BS is effective and has enhanced metabolic markers like blood glucose levels, blood pressure, and lipid profile measurements. The surgical techniques are usually restrictive mechanisms and malabsorption techniques including gastric bypass, sleeve gastrectomy, and adjustable gastric banding. Meanwhile, obesity as a multifactorial disease [3] is prevalent globally, and as a result, it requires huge capital for therapeutic cures. Type 2 diabetes mellitus (T2DM), hypertension, and depression are just a few of the various disease conditions that are most frequently comorbid with obesity, which is a progressive chronic condition [4]. Therefore, studies have shown that BS reverses significantly reverses and improves the health status of morbidly obese patients. The major techniques used are either restrictive surgical techniques (RST) or duodenal switches. The patient experiences satiety after restrictive surgery because it creates a gastric reservoir

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with a narrow outlet. Restrictive surgery is usually used for BS patients whose body mass index (BMI) is <50 Kg/m2. Examples of restrictive surgical techniques include vertical gastrectomy or laparoscopic vertical sleeve gastrectomy (LVSG) which are becoming popular globally in the treatment of obesity [5]. Other techniques include Roux-entry Bypass (RYGB), a mixed restrictive surgical technique that limits food and malabsorption because of the mechanical bypass to the jejunum. Mini gastric bypass or one gastric anastomosis (NGO-OA-GBP) ranked 3rd in popularity of commonly performed technique in BS. It has a short operative time, singular anastomosis, and offers comprehensive weight loss [6]. Although it is gaining popularity, a lot of controversies hindered its usage [7]. Restrictive surgery has also mixed surgical techniques like biliopancreatic diversion, and gastro-ileal bypass [7]. Besides, the duodenal switch is an alternative technique to gastrectomy. For instance, in single anastomosis duodenal bypass (SADI-S), a safe technique is established which has 34% to 38 % accuracy in weight reduction. Nonetheless, BS has longed been established and among the approaches of BS in use till today include Roux-en-Y gastric bypass (RYGB), laparoscopic vertical sleeve gastrectomy (LGSV), adjustable gastric band (AGB), and gastric bypass. There are several types of gastric bypass surgery, including Mini Gastric Bypass-One Anastomosis Gastric Bypass (MGB-OAGBP), SADI-S), open RYGB, Biliopancreatic Diversion with Duodenal Switch (BPD-DS), (MGB) and OAGBP.

Roux-en-Y gastric bypass (RYGB)

RYGB has been in existence for the past 40 years and it is regarded as the most effective BS procedure when effectively utilized. RYGB restricts food intake and hinders the release of gastrointestinal hormones that regulate metabolism, hunger, and food intake. Furthermore, hormones like incretins, glucagon-like peptide-1 (GLP-1), and peptide YY (PYY) [8] affect glucose homeostasis and satiety after RYGB. Ghrelin (hunger hormone) secreted by the enteroendocrine cell in the digestive system is also reduced following RYGB. Despite RYGB's status as the gold standard for obesity, it is associated with metabolic disorders, complex procedures, and marginally increased surgical risk when compared to sleeve gastrectomy.

Laparoscopic vertical sleeve gastrectomy (LGSV)

LGSV has recently a common surgical procedure for obese patients following the unpopularity of RYGB. LGSV involves an 80% vertical gastric resection and a neuro-hormonal modification that lowers Ghrelin. According to Lo T, Tavakkoli, Koch TR, and Shope TR [1,9], ghrelin is produced by the oxyntic glands located at the base of the fundus and corpus which has proximity to the parietal cell. LGSV is associated with complications such as increased gastric reflux, anastomosis, infection, etc. Irrespective of its increasing popularity, LGSV mortality, and morbidity rate ranks at 1.2% and up to 17.5% respectively [9].

Laparoscopy Adjustable Gastric Band (LAGB)

This is performed in the management of increasing cases of morbid obesity. Even though laparoscopic adjustable gastric banding (LAGB) is less intrusive compared to other forms of bariatric surgery, it also has several observations that might cause nonspecific abdominal symptoms (NSAS) for several months or even years following the surgery [10]. The rate of complications was significantly higher for LAGB than for LGSV and RYGB. About 21% of patients for LAGB require surgical revision, while only 9% of LSG patients undergo RYGB conversion. LAGB is a restriction bariatric procedure that works on the principle of encircling the fundus using different synthetic grafts and restricting the route to the distal region of the stomach to create a tiny volume pouch close to the stomach thereby reducing one's food consumption rate [10]. Additionally, in a 30-day adverse evaluation, LAGB recorded 2.9%, LGSV was 2.6%, and RYGB was 5.0% [10].

Biliopancreatic diversion (BPD) with a duodenal switch

BPD with a duodenal switch was initially described in 1979 by Scorpinaro [11]. BPD is used surgically in the treatment of obesity. The surgeon makes an intestinal bypass that connects the ileum to the duodenum via a bypass aimed at reducing food calories. In general, BPD combines the ileum and duodenum through reticular malabsorption and it is regarded as the most effective among all bariatric interventions for obesity treatment.

Mini gastric bypass (MGB)

MGB is a variant of Roux-en-Y gastric bypass (RYGB) that only requires a single anastomosis [12]. The goal of this surgery is to help people who are morbidly obese lose a substantial amount of weight. The surgeon creates the gastric pouch that resembles sleeve gastrectomy then a bypass is created on the intestines which reduces the body's ability to take in nutrients and calories from diet. The MGB limits morbidity and poor absorption. It is simpler and shorter compared to the RYGB and correlated with fewer serious side effects such as bleeding, leakage, blood clots, gastrointestinal tract (GIT) issues, and bile reflux.

2. THE CONCEPT OF ROBOTICS IN BARIATRIC SURGERY AND ITS INCREASING SIGNIFICANCE

Obesity has increasingly become a global epidemic, overwhelmingly, its attendant health problems now have a viable long-term solution in the form of BS. Recent developments in the field of bariatric health have led to a renewed interest in the use of robots in BS [13]. It offers to revolutionize current methods of treatment. Robotic technology is becoming increasingly important in the field of bariatric surgery because it improves doctors' visibility, dexterity, and quality of life for their patients. The robotic system consists of a master console [14] that controls robotic arms that carry surgical tools. These articulating devices and 3D imaging provide the surgeon with more control and precision during the operation. The robotic arms accurately replicate the surgeon's hand movements, reducing the chance of accidental tissue damage and improving surgical outcomes. Robotics through high definition (HD) 3D imaging offers numerous benefits for BS. It allows for better visibility, giving surgeons a more complete picture of the surgical site for more precise identification of anatomical components and careful manipulation. Robotic devices, with their enhanced dexterity, make the performance of complex and delicate tasks easier and safer [15]. Due to the tiny incisions used for robotic surgery, patients may experience less pain and recover from their procedures more quickly. However, the focus of every BS technique is to reduce pain, which is accomplished by altering the structure of the digestive tract in a way that results in decreased hunger and/or poor nutrient absorption. Robotic-assisted surgery (RAS) offers new opportunities to overcome some of the drawbacks of classic laparoscopic techniques, which have been used for many years in BS [16]. An ever-expanding amount of evidence highlighting the potential benefits of robots in BS highlights the field's rising importance. Patients have better results, fewer complications, and shorter hospital stays after a RBS. Notably, the long-term weight loss results and remission rates of obesity-related comorbidities have been equivalent to or better with robotic-assisted procedures, through better visualization, more precise surgery, less invasive procedures, better patient outcomes, and more comfortable surgical ergonomics [18]. Firstly, for better visualization, robotic equipment has an HD-3D technique that gives surgeons a better view of the surgical site linearly or circularly featured estimation to different shapes of objects. For instance, the hybrid visual servoing device, according to Peng et al [19] has calibrating and model error robustness and above all an increased convergence velocity thereby providing the surgeon with an independent ocular visualization. On top of that, surgeons can conduct complex surgical operations with absolute precision and articulation capabilities [15]. According to Peters et al. [20] , it is a trending technique that focuses on the complete reduction of patient trauma [20], for instance, through percutaneous interventions such as targeted needle biopsies and other diagnostic procedures. Besides traumatic intervention, RBS provides sufficient surgical data for the surgeon and researchers through multiple-sense feedback and novelty in the image sensors. Meanwhile, RBS has shown that the patient's well-being is improved through decreased body weight, remission of comorbidities, a greater quality of lifestyle, and especially longevity in health, unlike the non-surgical methods. Again, RBS has led to a reduction in mortality and cardiovascular disease. To the surgeon, it offers good ergonomic practices to reduce physical stress and maintain a good body posture afterward [22]. Furthermore, robots have revolutionized BS nevertheless, it is a capital-intensive technique and is mostly seen in research facilities.

Artificial intelligence (AI) in robotics for BS

The concepts of AI and robotic systems are central to the enhancement of BS. AI including ML models has helped surgeons make intelligent surgical interventions for overweight individuals. The diagnostic images, electronic health records (EHR), and other patient data, together with clinical variables, can all be analyzed by AI algorithms to aid in pre-operative planning for surgery. Besides, surgical results can be optimized and anticipated with the help of ML algorithms that provide data on each patient's anatomical variability [23]. Again, AI identifies potential risks associated with or that may influence the decisions or outcome of the surgery. For example, AI identifies the risk through the patient's medical history, comorbidities, body makeup, and then a personalized surgical plan is created [24]. Additionally, AI models are often used in the analysis of real-time data generated from the robotic platform. Nevertheless, AI-RBS offers automation of surgical intelligence. The models when deployed, learn from the individualized anatomies and make predictions. The AI model helps in instrument optimization thereby improving surgical ergonomics, reducing surgical time frames, and easing the learning curve for robotic-assisted bariatric procedures. Likewise, AI robotic BS is used in post-operative BS as well as predictive analysis. AI models are well-versed in the analysis of data after bariatric surgery such as clinical lab results, and patients’ vital signs. The ML model could be used as postoperative data to predict infections, recovery rates, and other patient outcomes [25].

3. MATERIALS AND METHODS

In this study, we used two different data collections. A single data set included a comprehensive collection of literary citations covering a wide range of topics related to bariatric surgery published between 2019 and 2023. The second dataset was obtained from the American Society for Metabolic and Bariatric Surgery: https://asmbs.org/resources/estimate-of-bariatric-surgery-numbers, a publicly accessible database for 2022 dataset showing an estimate on the number of BS performed between the years 2011 to 2021. The data was obtained by downloading it from the webpage. The downloaded file with the file name: Estimate of BSN 2011-2022 was arranged in 12 columns and 11 rows. The columns were labeled with the specific year: 2021, 2020, 2019, 2018, 2017, 2016, 2015, 2014, 2013, 2012, and 2011 while the rows were labeled as Sleeve, RYGB, Band, BPD-DS, Revision, SADI, OAGB, OAGB, Others, ESG, Balloons, and the total respectively. In this study, Microsoft Office Professional 2019 which contains product Excel is used for the evaluations. The Microsoft Excel version 2019, 64-bit with Product ID 00414-50000-00000-AA394 and Session ID 60157273-9559-4512-B235-FDF5E8CD2465 was used. Excel is used in the cleaning of the data to remove noise and as well fill in the missing numbers in the original data. The missing values were replaced using the mean from descriptive statistical analysis also found in Excel. Excel's built-in functions make it convenient for imputation and normalization. The normalized data reduced bias and increased dataset convergence, which allows for the optimal performance of models. The normalized data are on a similar scale, thus making the algorithm more effective. The normalization will help us to calculate the distances in the k-nearest neighbors (KNN) ML algorithm and clusters. Above all the normalized data ensures stability in the statistical evaluation such as regression analysis as well as visualization of the plotted graphs. We then uploaded the normalized data into MATLAB for analysis.

Cluster analysis

Cluster analyses (CA) are unsupervised ML methods to identify and separate similar but distinct groupings within a given dataset. This distinguishing feature is largely responsible for the growing preference for cluster analysis over more conventional methods of statistical analysis. For example, Seeras et al.[26] have demonstrated the benefit of clustering analysis in medical studies. CA is an essential resource for large datasets, classifying data into meaningful categories, as well as deducing meaning from unstructured data. Therefore, in this study, the rationale behind CA on BS identifies natural patterns in the BS dataset. Clustering shows the in-depth similarities and differences between the diverse surgical procedures i.e. separating the data into subcategories. Also, the result from CA helps surgeons and decision makers to outline individualized treatment alternatives, especially in patients with post-operative care (POC) and follow-ups. Meanwhile, apart from the evaluation of new trends in BS, clustering a large dataset of BS benefits researchers whose result reveals complication and safety procedure. Also, CA serves as a benchmark for quality controls and early detection of disorders associated with morbid obesity.

Fuzzy Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE)

In the early 1980s, J.P. Brans and B. Mareschal [27] created a method of MCDA called PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluations). J.P. Brans and B. Mareschal developed PROMETHEE in other to make informed decisions when faced with many alternatives. PROMETHEE methodology has long been applied in commercial operations, engineering, health, and environmental governance [28–32]. The principle is based on a pairwise comparison strategy, where each alternative is compared to all alternatives according to specific criteria. In PROMETHEE, the preference function of the criteria, their weights, and the purpose of the criteria (maximum or minimum) are determined by the expert. Preference indices are calculated from the pairwise comparison results and show the overall preference for a specific alternative over another based on every criterion. A net flow value is then calculated for each alternative based on the aggregate of these indices using an established aggregation method. PROMETHEE is beneficial in solving multi-criteria decision-making (MCDM) problems. It clarifies the connections between the various factors that affect decisions and helps decision-makers obtain insights into balances of criteria and alternatives. In addition, PROMETHEE allows for a clearer and more organized decision-making procedure. However, PROMETHEE is not without its flaws, since the criteria weights and preference functions are fundamentally subjective and may vary depending on the perspective of the decision-maker, this is a critical factor to consider. Getting reliable and consistent weights for criteria remains difficult in practice, especially when many stakeholders have varying perspectives to consider. Again, the computational and time-consuming nature of the pairwise comparison procedure in PROMETHEE hinders its efficacy, especially in a large data set. Meanwhile, in this study, we highlight the PROMETHEE method's inherent fuzziness, which introduced imprecision and enabled decision-makers to articulate their preferences. To rank the alternatives in enrichment evaluations, the PROMETHEE utilizes fuzzy sets to represent ambiguity in decision data. This approach equips decision-makers to competently deal with complicated and unpredictable information, making it a useful tool for decision support in a wide range of real-world contexts. This study used the dataset from Table 1 for the PROMETHEE evaluations.

Table 1. Dataset for PROMETHEE evaluation

Alternatives	TBWL (%)	Bleeding (%)	Operative time (Min)	LOS (days)	30days ROR	PR (%)	key complications	CR (%)	ECR (%)	LCR	MR (%)	MDR (%)	LR (%)
VSG	15[33]	1.16 [34]	130	3[18]	2.5 [17]	55	anastomosis, leak, gastric reflux, POB, infection	2.6	2.2-2.4	GPD, stricture. gallstones, hiatal hernia, ITSM, GERD	0.36	5.8 [18]	1.5–3[19]
RYGB	72 [17]	1.38	101	2	1.6	39.6 [5]	abdominal pain, leak, stomach ulcer, IO, gallstones, NC, weight regain	13	10-16	mesenteric herniation, intestinal strictures, long-term Vit B12, Iron, calcium, and folate	0.05	3.8 [19]	0.36
AGE	22.2	0.50	122	1-3	8.9	42	pouch dilation, port prominence, malfunction, gastroesophageal reflux, band slippage, SBO	5	2.5-3.6	GPD, intra-gastric erosion, peroration, tube migration, disconnection, infection, SBO	0.05	0.2	0.68
BP-DS	49.2	0.99	264	4	7	37.3	mortality, wound, leak infections, VTE, bleeding, bowel obstruction,	26.7	2.7	hernia, GI malabsorption, NC	0.29-1.23[22]	0.01	0.89
SADI-S	35	0.63	100–155	3	3	44.5		14.8	2.65	NC, diarrhea, duodenal switch, efferent, afferent loop	0.01	0.01	0.14
Open RYGB	45	1.1-4[25]	100–155	2.6	9.5	45.9 [5]	GPD, band erosion, leaks, weight regain	7.5	0.16 [35]	GGF, SBO, DS, NC [26]	0.3	1–2	0.6
Lap AGB	70	0.6[25]	123	2–17 [26]	10.3	1[5]	weight gain, increase in a pouch, band slip, erosion, port infections, breakage	9	1.7	Band slip, Band erosion, infection, IAA,	0.05–0.1	0.01	0.4–5.2

MGB-OAGBP	76.6	0.3	90–120	1.36	4.7	44.8	Bleeding, leaks, perforation of the bowel, stenosis.	10.9 [22]	2	Marginal ulcer, stenosis, Steatorrhea, Internal hernias, Gastric leak, weight regain, anemia	0.1	0.01	7.4 55

Key: Single anastomosis or Single anastomosis duodena-ileal bypass with sleeve gastrectomy (SADI-S), length of hospital stays (LOS), Late Complication rate (LCR), Early Complication rate (ECR), Reoperation Rate (ROR), Intrathoracic sleeve migration (ITSM), small bowel obstruction(SBO), Gastro-Gastric Fistula (GGF), Nutritional Complications(NC), Dumping Syndrome (DS), gastroesophageal reflux disease (GERD), post-operation bleeding(POB), venous thromboembolism(VTE), intestinal obstruction (IO), Intra-abdominal abscess(IAA), Gastric pouch dilatation (GPD), Vertical sleeve Gastrectomy(VSG), Total Body Weight Loss (TBWL), Complication rate (CR), mortality rate (MR), Morbidity rate (MDR), Leak rate (LR) and Popularity rate (PR), Roux-en-Y gastric bypass (RYGB), Adjustable Gastric Band (AGB), Biliopancreatic Diversion with Duodenal Switch (BPD-DS), Laparoscopic Adjustable Gastric Band (Lap AGB), Mini Gastric Bypass One Anastomosis Gastric Bypass (MGB -OAGBP). Open Roux-en-Y gastric bypass (Open RYGB), Vitamin B12 (Vit B12) [33], [18], [17], [19], [5], [22], [25],[34], and [26] are references from which the corresponding data values were gotten

Criteria Weights

Within the context of the PROMETHEE technique, the simultaneous use of weighting methods to assign relative priority to the criteria utilized in the decision-making process is a key component. This study makes extensive use of linguistic scaling because it is particularly useful for dealing with complex and uncertain decision problems in circumstances where precise numerical data is either unavailable or impossible to obtain. Linguistic scaling can make decisions or combine qualitative evaluations in a methodical and thorough approach. The alternatives from Table 1 data were simulated into PROMETHEE methodology based on the criteria and its preferences such as weight, maximum/minimum (max/min) and the preference function as can be seen in Table 2.

Table 2. Criteria and Preference functions

Alternative	Min/max	Weight	PF
TBWL(%)	Max	0.92	G
Bleeding	Min	0.75	G
Operative time (min)	Min	0.25	G
LOS (day)	Min	0.5	G
30days ROR	Min	0.08	G
PR	Max	0.25	G
Key complications	Min	0.08	G
CR (%)	Min	0.5	G
ECR (%)	Min	0.5	G
LCR	Min	0.5	G
MR (%)	Min	0.08	G
MDR (%)	Min	0.5	G
LR (%)	Min	0.5	G

Key: Gaussian (G), Preference function (PF)

- **TBWL**: TBWL (%) is a very important metric in BS because it quantifies the percentage of reduced weight compared to the original weight after surgical intervention. It was assigned a very high weight of 0.92
- **Bleeding:** Bleeding is the amount of blood loss by the patient during and after BS. This metrics evaluates the safety of the surgery, other post-surgery complications, and its management.
- **Operative time**: This is the duration from the onset of the surgery, i.e., the incision, to the end of the surgery. It helps in surgical efficiency and protocols.
- **LOS:** LOS evaluates the duration of a patient's stay in the hospital after BS. It also evaluates recovery rate and management evaluations.
- **The 30-day ROR**: This is the rate at which the patient undergoes another surgery within 30 days after the first surgical procedure. It is also an indicator of post-surgical operations.
- **Popularity rate (PR) (%)**: This entails the degree to which types of BS techniques are in vogue compared to other procedures. Popularity rate influences treatment options because of the trending techniques and influences.
- **Key complications**: They are the adverse effects of BS including bacterial infection at surgical sites. Its measurement ensures patient safety.

- **CR:** CR is the overall adverse postsurgical effects. It ensures the overall challenges the patient undergoes during recovery face.
- **ECR**: ECR occurs shortly after BS i.e. it is an immediate post-surgical complication, however, timely intervention ensures patient support.
- **LCR**: In late complication late, we access the complication beyond the post-operative phase of BS.
- **Mortality Rate (MR) (%):** The mortality metric quantifies the number of patients who experience fatality during BS. With this, the safety of BS and its interventions are evaluated.
- **Morbidity Rate (MDR) (%)**: This is the measurement of non-fatal adverse conditions in order of their degree of severity. Morbidity rate refines surgical techniques in BS.
- **Leak rate (LR) (%):** Leak rate is the percentage of the patient that experiences perforations at the staple line after BS. In summary, TBWL (%) and bleeding (%) were assigned a very high weight. LOS (days), CR (%), ECR (%), LCR, Morbidity rate (%), and Leak rate (%) were all of a moderate importance weight of (0.5) compared to other criteria. Again, 30 days ROR, key complications, and Mortality rate (%) were assigned a very low weight of 0.08 because they are the least significant criteria in the study. Similarly, Operative time (Min), and Popularity rate (%) were assigned a low weight of 0.25 because they are of less importance in the decision-making process. However, recent developments in robots have introduced innovative possibilities for BS, providing an opportunity to improve surgical precision and patient outcomes. Therefore, in this study, we examine how RBS might benefit from the application of PROMETHEE. Also, to learn more about the potential benefits, drawbacks, and difficulties of using the aforementioned techniques in robotic-assisted bariatric surgeries.

4. RESULTS AND DISCUSSIONS

To make educated decisions and develop more specific post-operative care strategies, the result of this study reveals an extensive clustering analysis that unveils the inherent structural components and categories within the BS dataset. The clustering analysis of the sample hit shows the number of samples that fall into the specific clusters. The hits show the nearest cluster nodes. Points in data that are assigned to a node in the Self-Organizing Maps (SOM) lattice are based on how closely they match the node's weight vector. According to Figure 1, the hit showed 11 points that are closer to the centroid.

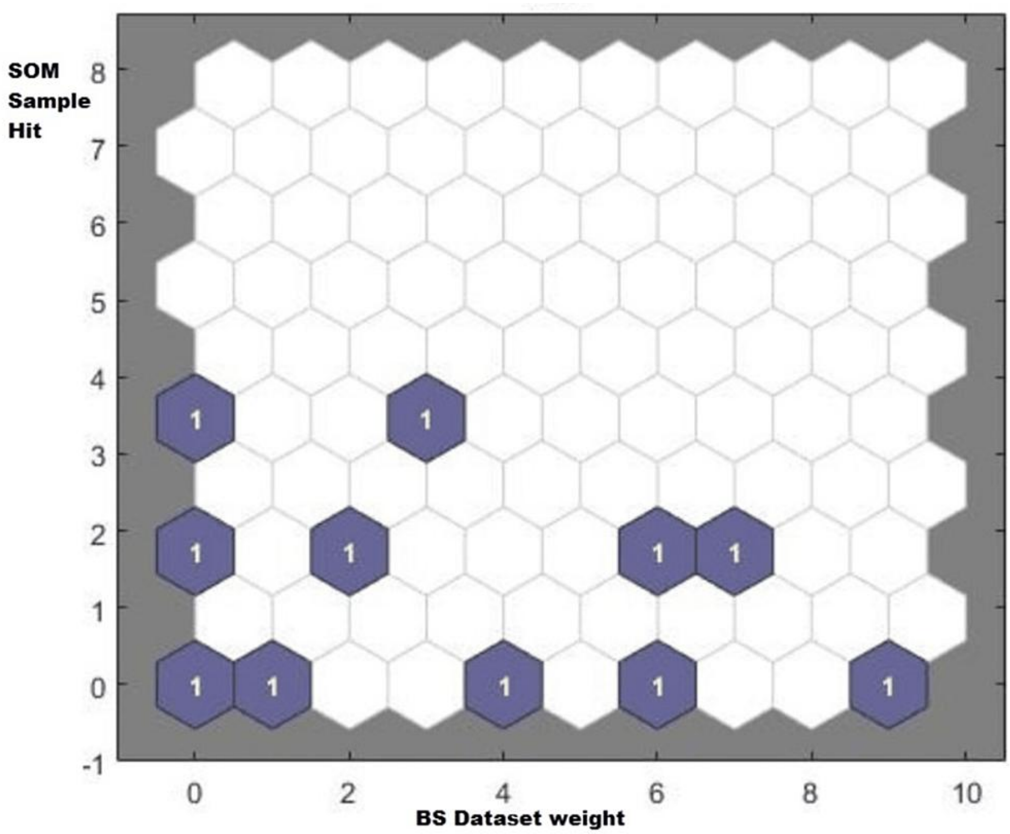


Figure 1. Bariatric clustering hits

The Self-Organizing Maps (SOM) neighbor weight distances

This clustering result showed that 100 matched the nearest node in the SOM lattice, and the lattice is then adjusted to make sure all of the nodes are evenly distributed over the input data. During training, the SOM's neighbor distances are calculated to show how close each node is to another. Thus, the neighboring neuron distances were represented with bright colors between bright colors with similar clusters whereas the colors are wide apart. The red smooth distribution of the dataset is represented by the thick red border while the similar light red is a dataset that is far apart as can be in Figure 2.

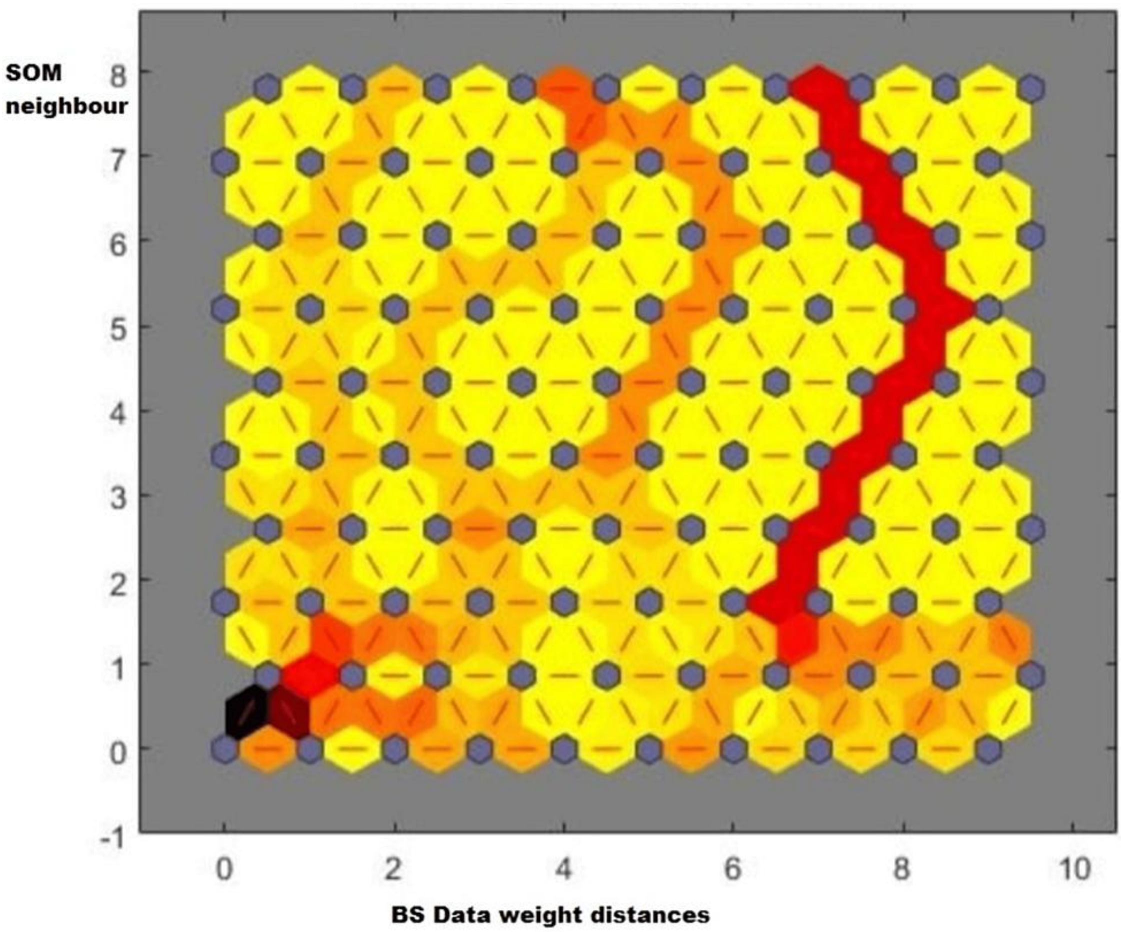
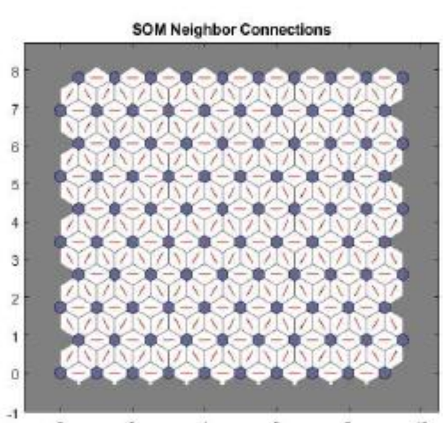


Figure 2. SOM Neighbor weight distances

Self-organizing maps (SOM) neighbor connection

These are connections among the SOM lattice's nodes (neurons). SOM neighbor connection employs unsupervised learning to reduce the number of dimensions used to represent bariatric data while maintaining its topological structure. Training a SOM involves assigning each data point to the node in the lattice that is closest to it and then adjusting the lattice so that it best fits the distribution of the input data. The results in the figure show that clusters of nodes representing comparable data points arise when nodes with direct connections have a greater chance of influencing each other's weights.



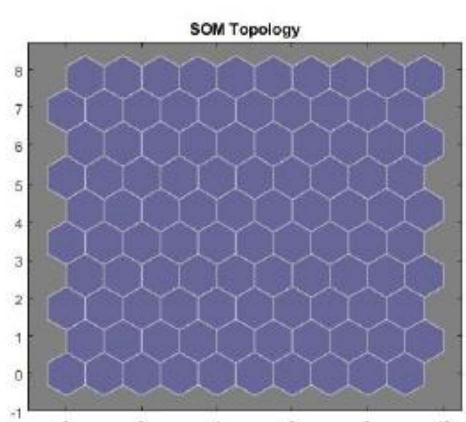


Figure 3. The SOM neighbor connection and SOM topology

A topological map is produced that accurately depicts the underlying data structure as a result of the nodes self-organizing and becoming experts in representing specific parts of the bariatric data. When it comes to clustering BS patients, the SOM's topology is vital. This is because it allows the SOM to recognize the underlying relationships between individual data points. The SOM neurons that are spatially closer together in a decreased dimension group comparable data point together, which enables the SOM to detect clusters of data. This allows the SOM to provide a readable map of the clusters.

Input weights plan

In weight plans, the result shows the result of the 100 neurons plan from the dataset Similar neurons are indications of features that are dependent while dissimilar parts are not dependent. The dependent features are represented in different shades of colors that can be seen in weight inputs A to K as in Figure 4

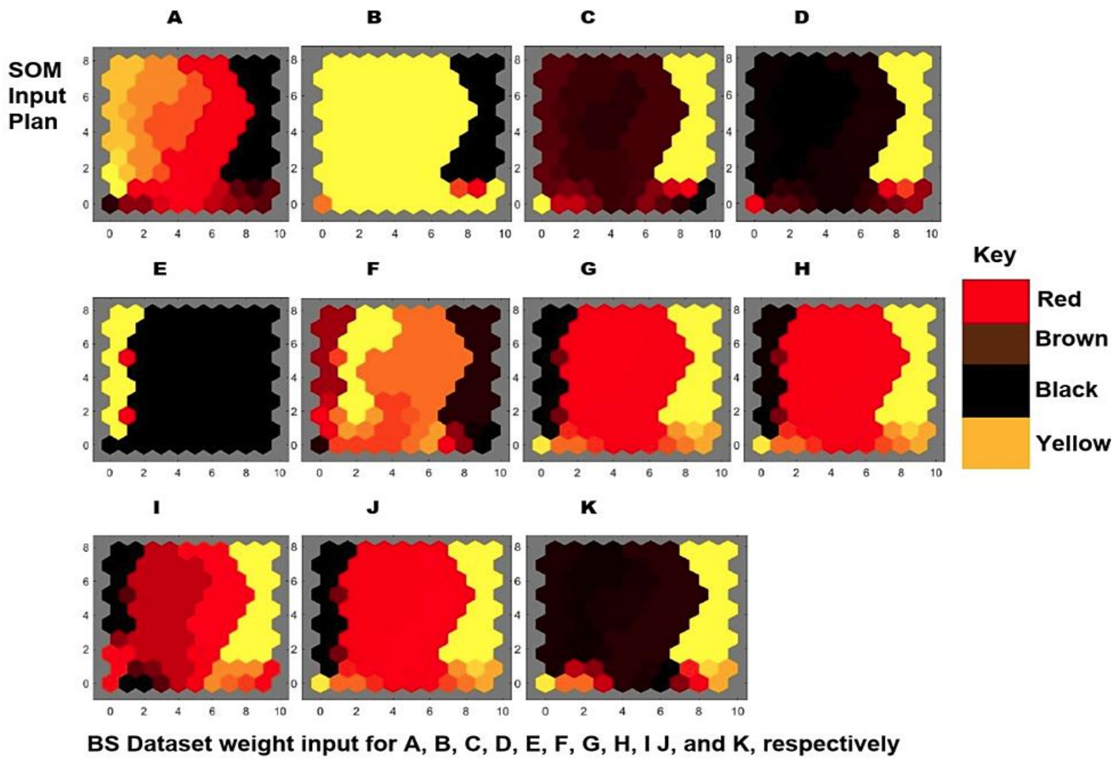


Figure 4. The weights from the inputs

Comparably, the red lines showed the neighboring neurons, neurons that represent the centroid clusters. These red lines also represent the average position of data points inside each cluster and can be used as a guide for arranging data into meaningful clusters. Again, the red lines of the clustering structure evaluate the algorithm's performance in producing evenly distributed groups. The BS data points with the strongest positive connection are represented in yellow, whereas the black points have the highest negative connections.

On the other hand, the PROMTHEE result showed that MGB-OAGBP ranked highest with 0.0051, 0.0081, and 0.0029 as net flow, positive, and negative outranking values, as can be seen in Table 3.

Table 3. PROMETHEE Net flow values

S/No	Action	Net flow values	Positive outranking value	Negative outranking value
1	MGB-OAGBP	0.0051	0.0081	0.0029
2	SADI-S	0.0037	0.0053	0.0016
3	AGB	0.0034	0.0057	0.0023

4	Open RYGB	0.0001	0.0044	0.0031
5	RYGB	-0.0003	0.0044	0.0043
6	Lap AGB	-0.0003	0.0043	0.0046
7	BP-DS	-0.0057	0.0022	0.0079
8	VSG	-0.0075	0.0027	0.0102

Similarly, Similarly, the PROMETHEE evaluation graph (Figure 5) showed that MGB-OAGBP ranked first, followed by SADI-S, AGB, Open RYGB, RYGB, Lap AGB, VSG, and Bp-DS, respectively.

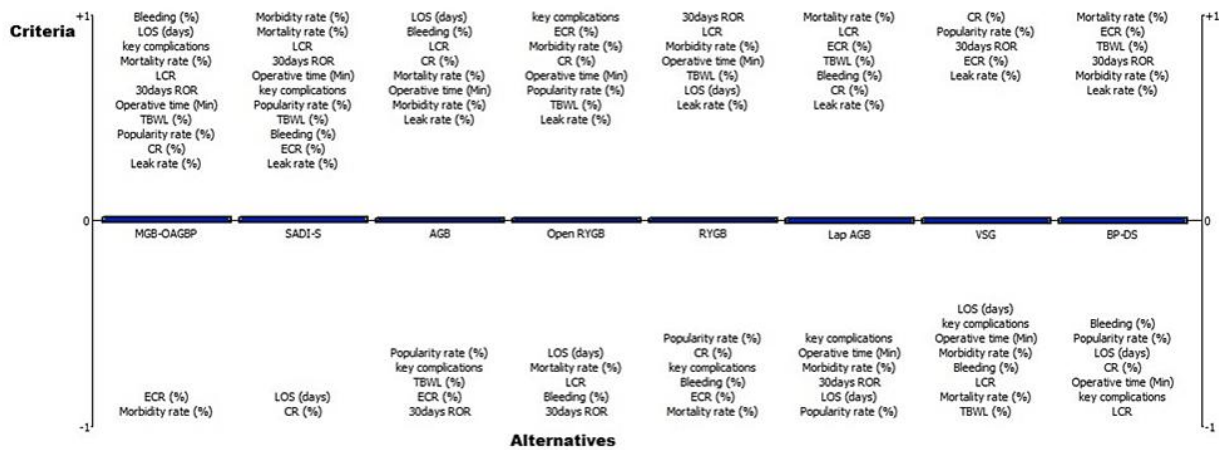


Figure 5. The PROMETHEE evaluation graph of the BS

In the context of this study, a comprehensive collection of literary citations covering a wide range of topics related to BS was published between 2019 and 2023 and was simulated using the PROMETHEE methodology. The second dataset was obtained from the American Society for Metabolic and Bariatric Surgery and was used for clustering analyses using MATLAB R 2021a (9.10.0.162886) 64-bit (win64), February 17, 2021. At the same time, the clustering always matches the PROMETHEE results, which show that MGB-OAGBP is the best BS method for making groups that are evenly spread out. The PROMETHEE results are shown in Table 3 in order of their increasing ranks. MGB-OAGBP ranked highest among the BS approaches used with a net flow value of 0.0051, a positive outranking value of 0.0081, and a negative value of 0.0029, as recorded in Table 2. MGB-OAGBP represents the highest preference for the BS procedure compared to the remaining alternatives. In the same way, simulating the data set in PROMETHEE creates different outranking flows, which can be seen visually on the PROMETHEE evaluation graph. The graph is a visual representation showing the preferences of the alternatives. In this graph, the individual alternatives are on the horizontal axis with their respective identifiers, while the vertical axis shows the strength of the preferences.

Additionally, the evaluation graph displays the preferred alternative that the bars indicate. However, MGBOAGBP ranked highest based on bleeding (%), LOS (days), key complications, mortality rate (%), LCR, 30-day ROR, operative time (min), TWBL (%), popularity (%), CR (%), and leak rate (%). The VSG and BP-DS were the least-ranked alternatives, as shown in Figure 5.

Future Perspectives and Limitations

According to this study, incorporating AI could significantly aid robotics development in BS. Therefore, several central ideas emerge that have the potential to shape the future of AI in BS. AI models have shown promise in improving the perioperative care of obese patients, but legal and ethical considerations have yet to be fully addressed. Alternatively, AI robotic systems have improved surgical automated equipment, which reduces manual surgical therapies. In most cases, high-quality data sets are not readily available, and the acquisition of these medical data requires regulatory standards [29]. Improved surgical personalization with AI will require continued study and improvement. So, approaches like personalized surgery and the improvement of algorithms-for instance, genomic information and responses to stimuli-improve surgery preparation and outcomes. To make a precise and reliable decision, AI models must be trained on vast datasets that include varied patient demographics and surgical scenarios. AI systems, especially deep learning (DL) models, frequently lack interpretability, thus making it difficult to make decisions. This has led to concerns about algorithm bias and safety for surgeons and patients. Again, models for disease prognosis and prediction are being developed and are heavily dependent on both the progress of

AI algorithms and the availability of high-quality data. To better serve a variety of patient demographics and surgical situations, these models require ongoing development and validation. Above all, in the future, there will be continual education integrating the knowledge of the AI instrument with that of younger surgeons [29]. According to Bellini et al. [30], AI tools are easily accessible due to the widespread availability of related hardware and software. Only the training and experience of participating doctors can ensure that their full potential is realized in the treatment they provide to their patients. It is still a problem that not everyone can afford to have access to the latest and greatest technological advancements. of the

5. CONCLUSION

In conclusion, BS is still an excellent alternative for morbidly obese patients with comorbidities. BS improves surgical accuracy and patient satisfaction. Because of their efficacy, robotic technologies were introduced to enhance performance and ensure greater patient safety with fewer complications. On top of that, AI was integrated, which has led to improved decision-making processes, allowing for better patient selection and better surgical strategies, especially through the use of PROMETHEE and clustering analysis. In the future, robotic procedures using AI algorithms will be improved to perform optimally in BS patient care. The integration of k-clustering analysis and PROMETHEE has progressed decision-making processes, enhancing individualization in patient selection and surgery planning. The result of the PROMETHEE showed that MGB-OAGBP ranked highest with 0.0051 as the net flow value.

Conflicts of Interest

The authors declare no conflicts of interest.

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REFERENCES

[1] Lo, T., & Tavakkoli, A. (2019). Bariatric surgery and its role in obesity pandemic. Current Opinion in Physiology, 12, 51–56. https://doi.org/10.1016/j.cophys.2019.09.002.

[2] El Ansari, W., & Elhag, W. (2021). Weight Regain and Insufficient Weight Loss After Bariatric Surgery: Definitions, Prevalence, Mechanisms, Predictors, Prevention and Management Strategies, and Knowledge Gaps—a Scoping Review. Obesity Surgery, 31(4), 1755–1766. https://doi.org/10.1007/s11695-020-05160.

[3] Chooi, Y. C., Ding, C., & Magkos, F. (2019). The epidemiology of obesity. Metabolism, 92, 6–10. https://doi.org/10.1016/j.metabol.2018.09.005.

[4] Biener, A., Cawley, J., & Meyerhoefer, C. (2017). The High and Rising Costs of Obesity to the US Health Care System. Journal of General Internal Medicine, 32(Suppl 1), 6–8. https://doi.org/10.1007/s11606-016-3968-8.

[5] Khaitan, L., & Shea, B. J. (2020). Laparoscopic vertical sleeve gastrectomy, long and short-term impact on weight loss and associated co-morbidities. Annals of Translational Medicine, 8(Suppl 1), S5. https://doi.org/10.21037/atm.2020.01.89.

[6] Parikh, M., Eisenberg, D., Johnson, J., & El-Chaar, M. (2018). American Society for Metabolic and Bariatric Surgery review of the literature on one-anastomosis gastric bypass. Surgery for Obesity and Related Diseases, 14(8), 1088–1092. https://doi.org/10.1016/j.soard.2018.04.017.

[7] Luesma, M. J., Fernando, J., Cantarero, I., Lucea, P., & Santander, S. (2022). Surgical Treatment of Obesity. Special Mention to Roux-en-Y Gastric Bypass and Vertical Gastrectomy. Frontiers in Endocrinology, 13, 867838. https://doi.org/10.3389/fendo.2022.867838.

[8] Magouliotis, D. E., Tasiopoulou, V. S., Sioka, E., Chatedaki, C., & Zacharoulis, D. (2017). Impact of Bariatric Surgery on Metabolic and Gut Microbiota Profile: A Systematic Review and Meta-analysis. Obesity Surgery, 27(5), 1345–1357. https://doi.org/10.1007/s11695-017-2595-8.

[9] Seeras, K., Sankararaman, S., & Lopez, P. P. (2023). Sleeve Gastrectomy. In StatPearls. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK519035/

[10] Gundogdu, E., & Moran, M. (2020). Adjustable gastric banding. Annals of Laparoscopic and Endoscopic Surgery, 6. https://doi.org/10.21037/ales-2019-bms-06.

[11] Sudan, R., Bennett, K. M., Jacobs, D. O., & Sudan, D. L. (2012). Multifactorial Analysis of the Learning Curve for Robot-Assisted Laparoscopic Biliopancreatic Diversion With Duodenal Switch. Annals of Surgery, 255(5), 940. https://doi.org/10.1097/SLA.0b013e31824c1d06.

[12] El Chaar, M., Stoltzfus, J., Elias, B., & Claos, L. (2017). A5283 - Laparoscopic Roux-en-Y Gastric Bypass vs. Mini Gastric Bypass: A Systematic Review of the Literature. Surgery for Obesity and Related Diseases, 13(10, Supplement), S192. https://doi.org/10.1016/j.soard.2017.09.425.

[13] Bauerle, W. B., Mody, P., Estep, A., Stoltzfus, J., & El Chaar, M. (2023). Current Trends in the Utilization of a Robotic Approach in the Field of Bariatric Surgery. Obesity Surgery, 33(2), 482–491. https://doi.org/10.1007/s11695-022-06378-1.

[14] Cepolina, F., & Razzoli, R. P. (2022). An introductory review of robotically assisted surgical systems. The International Journal of Medical Robotics + Computer Assisted Surgery, 18(4), e2409. https://doi.org/10.1002/rcs.2409.

[15] Klodmann, J., Schlenk, C., Hellings-Kuß, A., Bahls, T., Unterhinninghofen, R., Albu-Schäffer, A., & Hirzinger, G. (2021). An Introduction to Robotically Assisted Surgical Systems: Current Developments and Focus Areas of Research. Current Robotics Reports, 2(3), 321–332. https://doi.org/10.1007/s43154-021-00064-3.

[16] Kulaylat, A. N., Richards, H., Yada, K., Coyle, D., Shelby, R., Onwuka, A. J., Aldrink, J. H., Diefenbach, K. A., & Michalsky, M. P. (2021). Comparative analysis of robotic-assisted versus laparoscopic cholecystectomy in pediatric patients. Journal of Pediatric Surgery, 56(10), 1876–1880. https://doi.org/10.1016/j.jpedsurg.2020.11.013.

[17] Barua, R., & Datta, S. (2023). Emerging Surgical Robotic Applications for Modern Minimally Invasive Surgery (MIS): In M. K. Habib (Ed.), Advances in Computational Intelligence and Robotics (pp. 314–332). IGI Global. https://doi.org/10.4018/978-1-6684-7791-5.ch014

[18] Han, J., Davids, J., Ashrafian, H., Darzi, A., Elson, D. S., & Sodergren, M. (2022). A systematic review of robotic surgery: From supervised paradigms to fully autonomous robotic approaches. The International Journal of Medical Robotics and Computer Assisted Surgery, 18(2), e2358. https://doi.org/10.1002/rcs.2358.

[19] Peng, Y.-C., Jivani, D., Radke, R. J., & Wen, J. (2020). Comparing Position- and Image-Based Visual Servoing for Robotic Assembly of Large Structures. 2020 IEEE 16th International Conference on Automation Science and Engineering (CASE), 1608–1613. https://doi.org/10.1109/CASE48305.2020.9217028.

[20] Peters, B. S., Armijo, P. R., Krause, C., Choudhury, S. A., & Oleynikov, D. (2018). Review of emerging surgical robotic technology. Surgical Endoscopy, 32(4), 1636–1655. https://doi.org/10.1007/s00464-018-6079-2.

[21] Powell-Wiley, T. M., Poirier, P., Burke, L. E., Després, J.-P., Gordon-Larsen, P., Lavie, C. J., Lear, S. A., Ndumele, C. E., Neeland, I. J., Sanders, P., St-Onge, M.-P., & American Heart Association Council on Lifestyle and Cardiometabolic Health; Council on Cardiovascular and Stroke Nursing; Council on Clinical Cardiology; Council on Epidemiology and Prevention; and Stroke Council. (2021). Obesity and Cardiovascular Disease: A Scientific Statement From the American Heart Association. Circulation, 143(21), e984–e1010. https://doi.org/10.1161/CIR.0000000000000973.

[22] Rosenblatt, P. L., McKinney, J., & Adams, S. R. (2013). Ergonomics in the operating room: Protecting the surgeon. Journal of Minimally Invasive Gynecology, 20(6), 744. https://doi.org/10.1016/j.jmig.2013.07.006.

[23] Zhou, X.-Y., Guo, Y., Shen, M., & Yang, G.-Z. (2020). Application of artificial intelligence in surgery. Frontiers of Medicine, 14(4), 417–430. https://doi.org/10.1007/s11684-020-0770-0.

[24] Benalcazar, D. A., & Cascella, M. (2023). Obesity Surgery Preoperative Assessment and Preparation. In StatPearls. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK546667/

[25] Kermansaravi, M., Shahmiri, S. S., DavarpanahJazi, A. H., Valizadeh, R., Berardi, G., Vitiello, A., Musella, M., & Carbajo, M. (2021). One Anastomosis/Mini-Gastric Bypass (OAGB/MGB) as Revisional Surgery Following Primary Restrictive Bariatric Procedures: A Systematic Review and Meta-Analysis. Obesity Surgery, 31(1), 370–383. https://doi.org/10.1007/s11695-020-05079-x.

[26] Seeras, K., Acho, R. J., & Lopez, P. P. (2023). Roux-en-Y Gastric Bypass Chronic Complications. In StatPearls. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK519489/

[27] Brans, J. P., Vincke, Ph., & Mareschal, B. (1986). How to select and how to rank projects: The Promethee method. European Journal of Operational Research, 24(2), 228–238. https://doi.org/10.1016/0377-2217(86)90044-5.

[28] Balcioglu, O., Ikechukwu Emegano, D., Uzun, B., Şahin, T., Ozsahin, I., & Uzun Ozsahin, D. (2023). Comparative evaluation of blood conservation techniques in cardiovascular surgery using multicriteria decision-making methods. 2023 Advances in Science and Engineering Technology International Conferences (ASET), 1–8. https://doi.org/10.1109/ASET56582.2023.10180430

[29] Uzun, B., Usanase, N., Ozsahin, D. U., & Ozsahin, I. (2024). The Application of the Multi-Criteria Decision-Making Model in the Risk Assessment of Cervical Cancer Complications. 2024 Advances in Science and Engineering Technology International Conferences (ASET), 1–5. https://doi.org/10.1109/ASET60340.2024.10708754

[30] Duwa, B., Onakpojeruo, E. P., Uzun, B., Ozsahin, I., & Ozsahin, D. U. (2022). Comparative Evaluation of 3D Filaments, Used in Additive Manufacturing of Biomedical Tools; Using Fuzzy Promethee. [Preprint]. In Review. https://doi.org/10.21203/rs.3.rs-2020207/v1

[31] Ozsahin, D. U., Ikechukwu Emegano, D., Uzun, B., & Ozsahin, I. (2024). A Comparative Study on Male Breast Cancer Treatment Alternatives Using a Multi-Criteria Decision-Making (MCDM) Approach. 2024 Advances in Science and Engineering Technology International Conferences (ASET), 1–5. https://doi.org/10.1109/ASET60340.2024.10708657

[32] Ozsahin, D. U., Gelisen, M. I., Taiwo, M., Agachan, Y., Rahi, D., & Uzun, B. (2021). Decision Analysis of the COVID-19 Vaccines. The EuroBiotech Journal, 5(s1), 20–25. https://doi.org/10.2478/ebtj-2021-0017.

[33] Yan, S., Tao, X., & Xu, D. (2021). High-precision robotic assembly system using three-dimensional vision. International Journal of Advanced Robotic Systems, 18(3), 17298814211027029. https://doi.org/10.1177/17298814211027029.

[34] Bellini, V., Valente, M., Turetti, M., Del Rio, P., Saturno, F., Maffezzoni, M., & Bignami, E. (2022). Current Applications of Artificial Intelligence in Bariatric Surgery. Obesity Surgery, 32(8), 2717–2733. https://doi.org/10.1007/s11695-022-06100-1.

Hany, M., Zidan, A., Elmongui, E., & Torensma, B. (2022). Revisional Roux-en-Y Gastric Bypass Versus Revisional One-Anastomosis Gastric Bypass After Failed Sleeve Gastrectomy: A Randomized Controlled Trial. Obesity Surgery, 32(11), 3491–3503. https://doi.org/10.1007/s11695-022-06266-8.