Comparison of analysis of skeletal muscle loss after one anastomosis gastric bypass by skeletal muscle mass index vs. bioelectrical impedance analysis

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The general loss of muscle mass is defined as sarcopenia. The term "**sarcopenic obesity**" describes the co-presence of sarcopenia and obesity. SMI is a surrogate parameter for sarcopenia and thus, a reduction of SMI is related to physical disability, increased morbidity and even mortality in surgical patients.

AIM

This study aims to investigate if the BIA as a common technique for estimating the post operative body composition in comparison with the SMI measured by MRI in a cohort of patients undergoing one anastomosis gastric bypass (OAGB).

I hereby declare that we have no potential conflict of interest to report

In 2000, Janssen et al., from assessments of body composition through BIA, proposed the SMM index for the definition of sarcopenia .

$$SM(kg)=[(h2/BIA\ resistance \times 0.401)+(gender \times 3.825)-(age \times 0.071)]+5.102$$

where height (h) is in centimeters and BIA resistance is in ohms. With regard to gender, M = 1 and F = 0. Age is in years

This equation has been developed and cross-validated by means of magnetic resonance measurements of whole-body SMM on a sample of 269 subjects with wide age (18–86 years) and BMI (16–48 kg/m2) ranges .

Magnetic Resonance Imaging:

- MRI is considered the gold standard as it is also able to evaluate intramuscular fat ; however, BIA is the most used tool in clinical practice for patients with obesity due to its low cost, wide availability, and portability

- Abdominal MRI exams were obtained using a 1.5 Tesla whole-body scanner following standard clinical protocols.

- The anatomical coverage was from the upper edge of the liver to beneath the third lumbar vertebra level.

- The analysis of single-layer images (CT scan or MRI) is used to quantify whole body muscle mass in vivo.

- The cross-sectional area of skeletal muscles (SMA, cm^2) at the level of the third lumbar vertebra (L3), normalized for height, can be used to calculate the skeletal muscle index (SMI, cm^2/m^2), which is linearly related to the whole-body muscle mass

SMI=SM(kg)/h(m)2.

Bioelectrical impedance analysis

- **The new generation of bioelectrical impedance devices , as InBody770®, which shows excellent correlation when compared with magnetic resonance imaging (MRI), as shown in the validation study .**

- **InBody770® adopts the method of multifrequency analysis using three different frequencies (5 kHz, 50 kHz, and 500 kHz) that allow measurements of internal and external cellular water, proteins, minerals, and fat.**

- **It measures body component resistance and capacitance by recording a voltage drop in applied current. Capacitance causes the current to lag behind the voltage, which creates a phase shift. This shift is quantified geometrically as the angular transformation—the phase angle.**

- **it is an appropriate method to assess the segmental distribution of lean body mass compared with dual-energy X-ray absorptiometry (DEXA) at lower cost**

The validity of bioelectrical impedance to detect changes in body composition in intervention programs was found in a study of Jebb et al.

Methods

This study is a single center study conducted from January 2022 to December 2023 on patients who underwent one anastomosis gastric bypass at Indraprastha Apollo Hospital, New Delhi, which is an OSSI accredited Center of Excellence.. We obtained written consent from all participants of the study

The inclusion criteria :

- Age between 18 and 65 years;
- Body mass index (BMI) ≥40 kg/m2;
- BMI ≥35–39.9 kg/m2 with at least one associated comorbidity (e.g., diabetes, hypertension, dyslipidemia, or obstructive sleep apnea syndrome)
- Willing to do follow up

The Exclusion criteria :

- Patients with contraindications for MRI
- Not willing or able to give informed consent.

Statistical analysis:

- **Mean and standard deviation were calculated for quantitative variables.**

- **Qualitative variables were quoted as absolute numbers and relative frequencies.**

- **With the range or interquartile range, the median was presented for skewed or ordinally scaled parameters. Changes in parameters between measurements were examined using analysis of variance for repeated measurements.**

- **For correlation analyses, Pearson correlation coefficient was determined.**

- **A test result was considered statistically significant if $p < 0.05$. Statistical analyses were performed using the SAS statistical analysis software (SAS release 9.4, Cary, NC, USA).**

Results

- A total of 17 patients were included in the study; four male and 13 female.
- The average age of the patients was 41.9 years.
- Mean initial body weight was 119.34 ± 11.86 kg and mean initial BMI was 42.96 ± 4.5 kg/m^2.
- All patients underwent OAGB.
- Among other elements of the preoperative preparation like psychological, endocrinology- and nutrition expert assessment, every patient has documented at least 2.5 h of self-organized physical activity per week.

Demographic Characteristics	(*n* = 17)
Age	
Mean ± SD (Range (Max – Min))	41.9 ± 11.1 (35 (61 – 26))
Age group	
<=35	6 (35.3)
36–46	6 (35.3)
>=47	5 (29.4)
Gender	
Male	4 (23.5)
Female	13 (76.5)

Results

Comorbidities	
No Secondary disease	7 (50.0)
Hypertension	5 (35.7)
Sleep Apnea	4 (28.6)
Diabetes	2 (14.3)
GERD	1 (7.1)
Knee arthrosis	1 (7.1)

	Mean ± SD (Range (Max – Min))
Initial body weight (kg)	119.34 ± 11.86 (47.6 (144.1 – 96.5))
Initial BMI (kg/m^2)	42.96 ± 4.5 (15.9 (52.3 – 36.4))
Initial SMI (cm^2/m^2)	2.65 ± 7.06 (28.39 (68.89 –5 40.5))

Table 2

Body composition and skeletal muscle index at the different time points.

	t1	t2	t3	t4
Body weight (kg)	119.34 ± 11.86	103.67 ± 14.89	97.25 ± 10.87	92.59 ± 8.96
BMI (kg/m^2)	42.96 ± 4.5	37.31 ± 5.69	34.72 ± 5.8	34.33 ± 4.62
Basal metabolic rate (kcal)	1685.29 ± 171.36	1558.24 ± 186.76	1546.36 ± 205.97	1547.14 ± 248.98
Phase angle (°)	6.38 ± 0.88	5.56 ± 0.93	5.31 ± 1.01	5.7 ± 1.26
TBW (kg)	44.39 ± 7.58	44.14 ± 7.64	44.57 ± 6.55	43.09 ± 7.15
LBM (kg)	63.38 ± 10.34	60.31 ± 47.30	60.89 ± 8.93	58.87 ± 9.79
ECM (kg)	29.55 ± 5.74	30.5 ± 5.87	31.52 ± 4.45	29.37 ± 4.81
BCM (kg)	33.83 ± 5.45	29.81 ± 5.90	29.38 ± 6.55	29.51 ± 7.83
Index (ECM/BCM)	0.88 ± 0.13	1.04 ± 0.19	1.11 ± 0.25	1.06 ± 0.36
BF (kg)	55.96 ± 6.97	43.36 ± 8.99	36.35 ± 7.79	33.71 ± 6.45
BF (%)	47.02 ± 5.04	41.70 ± 6.01	37.28 ± 6.20	36.59 ± 6.66
SMA (cm^2)	146.73 ± 23.96	127.82 ± 24.71	124.22 ± 23.76	116.42 ± 29.37
SMI (cm^2/m^2)	52.65 ± 7.06	45.67 ± 6.62	43.84 ± 7.14	42.48 ± 7.86

- Results are presented as mean ± standard deviation. t1 = before surgery, t2 = 6 weeks after surgery, t3 = 12 weeks after surgery, t4 = 24 weeks after surgery. BMI = body mass index, TBW = total body water, LBM = lean body mass, ECM = extracellular mass, BCM = body cell mass, BF = body fat, SMA = skeletal muscle area, SMI = skeletal muscle index.

Table 2 shows the mean values of the respective parameters measured by BIA and the SMI measured by MRI as described above

- There were no postoperative surgical complications.
- MRI, as well as BIA, was performed one day before surgery (t1) as well as 6 weeks (t2), 12 weeks (t3) and 24 weeks (t4) after surgery.
- Measurements at t1 and t2 were complete for all patients while at t3 and t4 they were only complete in 11 and 7 patients, respectively.

- Applying the cut-offs for sarcopenia introduced by Prado et al. (SMI < 52.4 cm^2/m^2 for men and <38.5 cm^2/m^2 for women), 12% of the patients were sarcopenic before surgery (one man and one woman)
- 17% were sarcopenic at 6 weeks after surgery
- 45% at 12 weeks after surgery
- 57% at 24 weeks after surgery.

Table 3

Comparison of BIA parameters between the different time points

	Body Weight	BMI	BMR (kcal)	Phase Angle	TBW	LBM	ECM	BCM	ECM/BCM	BF (kg)	BF (%)	SMA	SMI
1 vs. 2	<0.0001	<0.0001	<0.0001	0.0007	0.0002	0.0002	0.6115	<0.0001	0.0075	<0.0001	0.0002	<0.0001	<0.0001
1 vs. 3	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	0.5693	<0.0001	0.0013	<0.0001	<0.0001	<0.0001	<0.0001
1 vs. 4	<0.0001	<0.0001	<0.0001	0.0052	<0.0001	<0.0001	0.9972	<0.0001	0.0079	<0.0001	<0.0001	<0.0001	<0.0001
2 vs. 3	0.0032	0.0045	0.4868	0.7336	0.7074	0.7029	0.9939	0.452	0.6751	0.0038	0.0074	0.5178	0.5735
2 vs. 4	<0.0001	<0.0001	0.0569	0.9557	0.0054	0.005	0.7076	0.0636	0.7784	0.0002	0.0015	0.0298	0.0416
3 vs. 4	0.1042	0.076	0.5251	0.9863	0.0658	0.0626	0.6024	0.5838	1	0.3965	0.7147	0.3509	0.3857

p-values for comparison between the respective time points. t1 = before surgery, t2 = 6 weeks after surgery, t3 = 12 weeks after surgery, t4 = 24 weeks after surgery. BMI = body mass index, TBW = total body water, LBM = lean body mass, ECM = extracellular mass, BCM = body cell mass, BF = body fat, SMA = skeletal muscle area, SMI = skeletal muscle index.

Table 3 shows *p*-values for the respective comparisons are given.

- Changes in body weight and BMI are significant between t1 and t2, t2 and t3, but not between t3 and t4.
- Overall, most pronounced changes are observed between t1 and t2 (before surgery and 6 weeks after surgery).
- As expected, the body fat is significantly reduced after bariatric surgery.
- We did not find any further significant reduction between t3 and t4.
- Nevertheless, the LBM as well as BCM and ECM/BCM Index changed after surgery with a significant reduction of LBM and BCM between t1 and t2 and an almost significant reduction when comparing t2 to t4.
- The reduction of BCM results in an increase of the ECM/BCM Index, indicating malnutrition.
- The muscle mass also decreased over the observed time period being displayed by SMA measurement in BIA and SMI measurement in MRI imaging.
- The reduction of muscle mass is significant comparing the status before and after surgery but also between t2 and t4.

Table 4

The Pearson Correlation Coefficient r for comparison of SMI with the parameters of body composition measured by BIA

t	Body Weight	BMI	BMR (kcal)	Phase Angle	TBW	LBM	ECM	BCM	ECM/BCM	BF (kg)	BF (%)	SMI
1	0.24085	0.38667	0.38526	0.22527	0.28819	0.28748	0.15098	0.3879	−0.24203	−0.0167	−0.18213	0.74816
2	0.42458	0.30951	0.66135	0.51569	0.476	0.4753	0.18051	0.66573	−0.50681	0.1514	−0.14671	0.82661
3	0.27591	0.2205	0.65462	0.72809	0.40136	0.40183	−0.16068	0.66083	−0.71336	−0.07564	−0.24256	0.79288
4	0.62821	0.18605	0.76101	0.71963	0.58433	0.58561	−0.05668	0.76404	−0.64093	−0.01619	−0.30592	0.87446

- No relevant correlation can be observed between BMI and SMI, but we found a correlation between the phase angle, BCM, ECM/BCM—Index and SMI.
- The higher the phase angle, the higher the SMI. The same applies to BCM. The higher the ratio of ECM/BCM, the lower the SMI.

Discussion

- **In the current study, we investigated the changes in the SMI measured on a single L3- MRI layer as a direct indicator for the skeletal muscle mass of obese patients undergoing a OAGB procedure compared to BIA.**

- **The SMI is rarely discussed in literature, concerning bariatric surgical patients, but it is widely recognized as a direct parameter of the muscle mass status, because of the high accuracy and low susceptibility to external factors, in many other fields of medicine**

- **Our results show a strong correlation between the SMI and the main parameters of the BIA (phase angle, LBM, BCM and the ECM/BCM—Index), which indicates that both methods are comparable in terms of estimating the change in body composition after bariatric surgery.**

These findings are in line with a publication of Walowski et al., considering that single computed tomography or MRI layers and appendicular lean soft tissue by DXA or BIA can be used as a valid substitute for total skeletal muscle mass. All diagnostics show a high correlation concerning body composition with results from whole body imaging in cross-sectional and longitudinal analyses

Conclusion

- Sarcopenia is a major problem in patients with obesity and can deteriorate further after bariatric surgery.
- Sarcopenia should be detected prior to surgery and an intense follow-up during the postoperative period.
- Our data verify the accuracy of the BIA- parameters for muscle mass in comparison to the exact measurement of the SMI in single L3 layer of the abdomen.
- Both methods can detect the condition of sarcopenia in bariatric patients as an important factor for body composition before and after surgery.
- Our results clearly show that BIA, performed under standardized setting, has a good applicability and precision as a direct, imaging measured method as the SMI determination.
- Structured programs, including an ongoing nutritional counseling and even structured rehabilitation programs, might be necessary to prevent patients from developing further sarcopenia and malnutrition


THANK YOU