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ORIGINAL ARTICLE

Peritoneal surface area: measurements of 40 structures covered by peritoneum: correlation between total peritoneal surface area and the surface calculated by formulas

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Abstract
Background We have not found studies that have measured the peritoneal surface area of each of the walls, organs, mesos, omenta, and peritoneal ligaments in a group of non-eviscerated human cadavers.
Objectives The objectives of this study were to obtain in fixed non-eviscerated cadavers: (1) the surface values of walls, organs, mesos, omenta, and peritoneal ligaments of each one and all the areas mentioned in the anatomy bibliography and their contribution to supra- and infra-colic portions, visceral and parietal portions of the supra- and infra-colic portions and the total peritoneal surface area, and (2) the relationship between the peritoneal surface values by direct measurement and the values obtained applying the formulas usually used in clinical practice to obtain body surface area.
Methods The peritoneal surface area of ten female human bodies presenting no abdominal pathologies were measured. They were fixed in 5% formaldehyde solution without the use of perfusion pumps and non-eviscerated, thus maintaining all structures intact. Cellophane was placed directly in situ onto all organs, mesos, omenta, ligaments and parietal walls. Digital imaging was obtained by scanning the models. A length reference was included and the surface was determined by the Scion Image program for Windows.
Results This paper provides for the first time data on each one and all the areas covered by the peritoneum. The total peritoneal surface area was (mean ± SE) 14,323.62 ± 824.37 cm^2. The two greater surfaces of peritoneum (39.21% of the total surface) correspond to the jejunum–ileum and its mesentery. The diaphragmatic peritoneum represented the greater area of parietal peritoneum. The supracolic surface was 4,487.46 ± 196.21 cm^2 (31.79 ± 1.50%) and the infracolic one of 9,836.16 ± 732.67 cm^2 (68.21 ± 1.50%). An interesting result of this work is that the surface of the parietal peritoneum in the supracolic abdomen (1,786.67 ± 92.58 cm^2, 68.56%) is more than twice that of the infracolic region (756.62 ± 55.91 cm^2, 31.44%). The visceral peritoneal surface (81.89 ± 0.99% of the total) was much higher than that of the parietal peritoneum (18.11 ± 0.99%). This difference is 12 times bigger in the infracolic abdomen. The peritoneal surface area measured in this study in non-eviscerated cadavers represents more than 96% of the one estimated by the above-mentioned formulas.
Conclusion The values shown in this paper would provide non-existing information for basic anatomy, and would contribute either to the study of pathologies involving the peritoneum or to their diagnosis and therapies.

Keywords Peritoneal surface area · Supracolic–infracolic peritoneum · Visceral–parietal peritoneum · Body surface areas formulas · Peritoneal dialysis

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Introduction

We have not found studies in the anatomy literature that have measured the peritoneal surface area in a group of non-eviscerated human cadavers. Research works

discussing the measurements of the peritoneal surface that correspond to each of the walls, organs, mesos, omenta, and peritoneal ligaments have not been found either. In the literature, we have not found measurements of the supracolic and infracolic surfaces nor measurements of the portions of the visceral and parietal portions corresponding to any of them. The values of these surfaces would provide non-existing information for basic anatomy and would contribute either to the study of pathologies involving these surfaces or to the possibility of finding the appropriate therapies for them [3, 4, 7, 11, 13, 16–18, 28, 29].

Measurements of the total peritoneal surface in human cadavers began in the nineteenth century. In 1870, Wegner, cited by Rubin et al. [25] studied one cadaver but never published his method. In 1884, Putiloff, cited by Esperanca and Collins [8], measured the peritoneal surface of one cadaver tracing outlines on oiled paper directly onto the peritoneum, but he did not provide body characteristics. In 1966, Esperanca and Collins [8] measured the peritoneal surface in six adult unfixed eviscerated cadavers. As regards the method that was used, they reported that "the abdominal viscera were removed and simply measured directly with a tape measure. Parietal peritoneum was measured in a similar fashion. For areas which would not lie flat (e.g., solid organs, pelvic peritoneum and particularly the small intestine) approximations were used, and the area probably underestimated". In 1988, Rubin et al. [25] also used unfixed and eviscerated cadavers and measured the peritoneal surface area that had been previously divided into seven regions. They said that the cellophane was placed directly onto parietal and visceral peritoneum and added that "care was taken not to overstretch these tissues". The cellophane tracings were used as patterns that were transferred to a standard weight paper and the surface area was calculated from the weight of the paper tracings.

For the last years, the new diagnostic tools have widely contributed to the study and treatment of diseases related to the peritoneum and the peritoneal cavity [3, 7, 24, 29].

The area in contact with the opaque fluid that was introduced in the peritoneal space, but not in contact with the rest of the peritoneal membrane was quantified through images.

When this contact area was measured using MRI in rats, it represented 30–40% according to Fischbach et al. [9] and according to Flessner et al. [10] a 25% of the total peritoneal surface. Chagnac et al. [5] applying CT-peritoneography in humans found that this contact surface was 30–60% of the total peritoneal surface evaluated by indirect means.

Rubin et al. [25] reported that "Wegner studied one female patient of middle age. Although he never described his method, he is referenced as demonstrating the "truth" that peritoneal surface area equals body surface area". From that moment onwards the peritoneal surface area has usually been evaluated in the clinical practice applying formulas that were first used to calculate the weight surface area [1, 6, 12, 15, 20]. In 1996, Pawlaczyk et al. [22] determined that in eviscerated and unfixed human cadavers, the total peritoneal surface represented a 75.9 ± 19.9% of the weight surface calculated using DuBois and DuBois formula [6].

The measurement of the peritoneal surface and of each of its areas could contribute to future basic and clinical studies.

The objectives of this study were to obtain in fixed non-eviscerated cadavers as follows:

1. The surface values of walls, organs, mesos, omenta, and peritoneal ligaments mentioned in the anatomy literature and their contribution to supra- and infracolic portions, visceral and parietal portions of the supra- and infra-colic portions and the total peritoneal surface area.
2. The relationship between the peritoneal surface values by direct measurement and the values obtained applying the formulas usually used in clinical practice to obtain body surface area.

Methods

Ten female human cadavers with ages ranging from 58 to 85 years were randomly assigned to this study. Their characteristics are shown in Table 1.

The following exclusion criteria were employed:

1. Abdominal pathologies or surgeries reported in the clinical history.
2. Observable abdominal scars.
3. Supplementary maneuvres for correct fixation.
4. Observation of unreported abdominal pathologies upon opening the abdomen.

Table 1 Human subject characteristics ($n = 10$)

	Mean ± SE	CV%
Age (years)	73.30 ± 3.01	12.99
Weight (kg)	49.51 ± 6.08	38.82
Height (cm)	163.90 ± 3.00	5.78
XPC (cm)	88.70 ± 3.41	12.15
UC (cm)	85.90 ± 4.38	16.13
IC (cm)	92.20 ± 4.69	16.07
XPPSL (cm)	34.80 ± 1.10	10.03

CV% coefficient of variation, *XPC* xiphoid process circumference, *UC* umbilical circumference, *IC* iliac circumference, *XPPSL* xiphoid process to pubis symphysis length

The cadavers were fixed in 5% formaldehyde during the first 72-h postmortem. The treatment of cadavers consisted of decreasing least possible the volume changes occurring during fixation.

Fixation process

1. Appropriate diameter catheters were placed in both femoral arteries through incisions located 2 cm below the inguinal ligament.
2. Small incisions were performed at the same level in both femoral veins.
3. Arterial catheters was located a height of 2 m above the body. The container was placed at this height so that the liquids would reach the body using a 140–150 Hg mm pressure similar to that of blood.
4. An isotonic sodium chloride solution was poured in the container and introduced by means of the catheter until the fluid leaving the veins was clear.
5. The fixing solution was introduced using the same route.
6. No perfusion pumps were used.
7. Color and consistency changes in the tissues (strengthening process) were considered criteria for good fixation.
8. The cadavers that were not appropriately fixed and that needed supplementary maneuvres to obtain a good fixation were excluded.
9. The cadavers were stored in 5% formaldehyde for at least 150 days before being processed in order to prove correct fixation and to ensure a stable volume.
10. The cadavers were weighed using a mechanical scale for adults before opening the abdominal cavities.

Measurement of the peritoneal surface area

A midline incision was made from xiphoid process to the pubic symphysis intersected by a transverse incision across the umbilicus. Except for these incisions of the parietal peritoneum, no other peritoneal serous membrane was sectioned during the procedure. This methodology allowed to preserve the morphology and the limits of the peritoneal organs and regions. The lesser sac was reached by blunt dissection separating the coalescence of the greater omentum from the transverse colon according to Lardennois and Okinczyk technique [19].

Forty areas covered by peritoneum according to Poirier and Charpy [23], Testut and Latarjet [26] and Gray [14] were measured.

All measurements were performed by at least two of the authors. The procedure was a laborious technique. Small cellophane films were placed directly onto the peritoneal surfaces successively one next to the other being in contact by the edges. All organs, mesos, omenta, peritoneal ligaments, and abdominal walls were covered. The cellophane portions were successively removed and duplicates were done in opaque paper. Digital imaging of the paper patterns was obtained by scanning referring to length. The surface was determined by the Scion Image program for Windows.

The results are expressed as mean ± SE and coefficient of variation of the mean reported as percentage (CV%). For the statistical study, the analysis of variance (ANOVA) and Pearson's correlation coefficient were used.

The "Dif CV%", the difference between CV% of absolute values and CV% of percentage values, shows the difference between the heterogeneity of both groups of values.

Reproducibility of the method

The reproducibility of the method was checked by measuring 18 times the same section of peritoneum with a mean ± SE of $25.75 \pm 0.11\ \text{cm}^2$ and a coefficient of variation of 1.83%.

Formulas used in clinical practice for the calculation of the total peritoneal surface area

In this work, the correspondence between the directly measured total peritoneal surface area and those estimated using formulas was statistically determined.

Formulas originally used by DuBois and DuBois [6], Boyd [1], Gehan and George [12], Haycock et al. [15] and Mosteller [20] for estimating body surface area were applied to measure the peritoneal surface area in each cadaver.

DuBois D and DuBois EF (1916) [6]

$$\text{Surface}\ (\text{m}^2) = 0.20247 \times \text{height}\ (\text{m})^{0.725} \times \text{weight}\ (\text{kg})^{0.425}$$

Boyd E (1935) [1]

$$\text{Surface}\ (\text{m}^2) = 0.0003207 \times \text{height}\ (\text{cm})^{0.3} \times \text{weight}\ (\text{grams})^{(0.7285-(0.0188\times \text{LOG(grams)}))}$$

Gehan EA and George SL (1970) [12]

$$\text{Surface}\ (\text{m}^2) = 0.0235 \times \text{height}\ (\text{cm})^{0.42246} \times \text{weight}\ (\text{kg})^{0.51456}$$

Haycock GB, Schwartz GJ, Wisotsky DH (1978) [15]

$$\text{Surface}\left(\text{m}^2\right) = 0.024265 \times \text{height}\ (\text{cm})^{0.3964} \times \text{weight}\ (\text{kg})^{0.5378}$$

Mosteller RD (1987) [20]

$$\text{Surface}\left(\text{m}^2\right) = \left([\text{height}\ (\text{cm}) \times \text{weight}\ (\text{kg})]/3600\right)^{1/2}$$

The correspondence between the peritoneal surface areas directly measured and those calculated by means of these formulas was statistically (ANOVA) determined.

For each case, the percentage corresponding to the values of total peritoneal surface areas measured in relation to the values estimated using formulas was calculated.

Results

The results of this work are shown in Tables 2, 3, 4, 5, 6and 7 and in Fig. 1. Tables 2, 3, 4 and 5 show the absolute and percentage contribution to the total peritoneal surface of the 40 areas considered in the measurement of peritoneal surface distributed according to their location in supracolic visceral, supracolic parietal, infracolic visceral and infracolic parietal surface areas. They are ordered by the decreasing values of their mean values.

The total area of the peritoneum was 14,323.62 ± 824.37 cm^2 (CV% = 18.20%). The ratio between the total peritoneal surface area and the body weight (mean ± SE) was 313.10 ± 25.71 cm^2/kg.

The two greater surfaces of peritoneum correspond to the jejunum–ileum and its mesentery. The sum of both represents 39.21% of the total of the peritoneum. As it is shown in the tables, the peritoneal areas following in descendent sequence correspond to the liver and the omentum. The greater portions of the parietal peritoneum correspond to the right and left diaphragmatic peritoneum and occupy the fifth and sixth place.

The supracolic surface was of 4,487.46 ± 196.21 and the infracolic of 9,836.16 ± 732.67 cm^2 and the corresponding CV% were 13.84 and 23.55%. The percentage contribution to the total peritoneum was 31.79 ± 1.50 and 68.21 ± 1.50% and their CV% was 14.94 and 6.97%, respectively.

The percentages of visceral and parietal peritoneum were 81.89 ± 0.99 and 18.11 ± 0.99%, respectively. This difference is greater in the infracolic region. The peritoneum parietal surface is significantly larger in the supracolic region (1,786.67 ± 92.58 cm^2) than in the infracolic one (756.62 ± 55.91 cm^2) (Fig. 1). The supracolic region represents 68.56% of the total parietal peritoneum, whereas the infracolic one represents 31.44%.

As it is shown in Tables 2, 3, 4 and 5, a positive sign of the DIF CV% indicates minor heterogeneity of percent values than those of the absolute ones. The highest positive DIF CV% correspond to mesentery, sigmoid colon, right and left hepatic triangular ligaments, abdominal esophagus, stomach and transverse colon. Consequently, these regions are the most proportional to the total peritoneal surface.

Table 2 Supracolic peritoneum: visceral area ($n = 10$)

	Surface area (cm^2)		Percentage (100% total peritoneal area)		Dif CV%
	Mean ± SE	CV%	Mean ± SE	CV%	
Liver	963.37 ± 77.86	25.56	6.82 ± 0.58	26.85	−1.29
Gastrocolic ligament	394.22 ± 36.38	29.18	2.82 ± 0.29	32.64	−3.46
Stomach	310.46 ± 23.31	23.75	2.16 ± 0.09	13.12	10.63
Spleen	172.25 ± 19.21	35.27	1.24 ± 0.15	39.61	−4.34
Transverse mesocolon: superior layer	162.31 ± 22.84	44.51	1.15 ± 0.17	45.86	−1.35
Lesser omentum	134.25 ± 18.21	42.89	0.94 ± 0.13	43.20	−0.31
Falciform ligament	130.11 ± 20.02	48.65	0.91 ± 0.14	48.85	−0.20
Pancreas	75.53 ± 4.70	19.69	0.53 ± 0.04	21.47	−1.78
Gastrosplenic ligament	71.48 ± 7.88	34.85	0.50 ± 0.05	30.74	4.11
Teres ligament	38.90 ± 5.61	45.59	0.27 ± 0.04	43.29	2.31
Duodenum	38.11 ± 5.95	49.39	0.27 ± 0.05	52.58	−3.19
Left triangular ligament	37.24 ± 6.25	53.09	0.25 ± 0.03	40.03	13.06
Gall bladder	29.95 ± 8.04	84.89	0.21 ± 0.06	91.46	−6.57
Lienorenal ligament	26.07 ± 3.32	40.22	0.18 ± 0.02	37.35	2.87
Right triangular ligament	22.50 ± 4.47	62.85	0.15 ± 0.02	46.34	16.50
Abdominal esophagus	17.69 ± 2.86	51.05	0.12 ± 0.01	38.87	12.18
Total	2,624.44 ± 147.54	17.78	18.55 ± 0.99	16.88	0.90

Table 3 Supracolic peritoneum: parietal area ($n = 10$)

	Surface area (cm^2)		Percentage (100% total peritoneal area)		Dif CV%
	Mean ± SE	CV%	Mean ± SE	CV%	
Right diaphragmatic wall	539.40 ± 36.33	21.30	3.86 ± 0.33	26.65	−5.35
Left diaphragmatic wall	481.76 ± 40.54	26.61	3.41 ± 0.29	26.48	0.13
Right antero-lateral supraumbilical wall	299.91 ± 29.36	30.95	2.13 ± 0.21	31.31	−0.35
Left antero-lateral supraumbilical wall	281.36 ± 21.38	24.02	1.99 ± 0.15	24.20	−0.18
Right dorsal supracolic parietal wall	184.25 ± 15.28	26.23	1.34 ± 0.14	32.74	−6.50
Left dorsal supracolic parietal wall	76.35 ± 15.41	63.84	0.54 ± 0.10	59.73	4.11
Total	1,863.02 ± 92.58	15.71	13.26 ± 0.81	19.32	−3.61

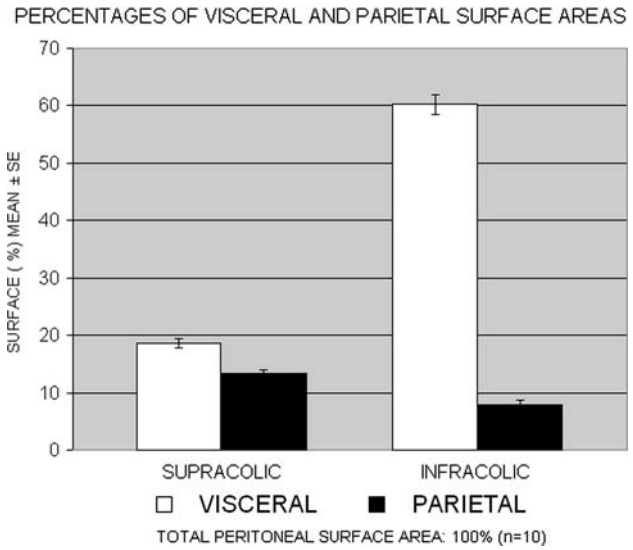

Fig. 1 Supracolic and infracolic peritoneal regions

Peritoneal surface area measured and calculated by formulas are shown in Table 6. They do not significantly differ among them, show high and significant Pearson's correlation coefficients and correlate significantly with the body weight (Table 7).

The ratio between total peritoneal surface area and the body weight (mean ± SE) was 313.10 ± 25.71 cm^2/kg.

The age, height, xiphoid process circumference, umbilical circumference, iliac circumference, and xiphoid process to pubis symphysis length do not significantly correlate with the peritoneal surface.

There is an important correspondence between the peritoneal surface measured and the body weight, as shown in the positive and statistically significant Pearson's correlation coefficient (0.793 $P < 0.04$) (Table 7). The corresponding regression line is: peritoneal surface (m^2) = 0.8987 m^2 + 0.0107 m^2/kg × kg (of body weight).

Discussion

In this paper, for the first time, the total peritoneal surface area was obtained from a series of cadavers measured in situ, i.e., in non-eviscerated abdomens. Peritoneal surface values were obtained from 40 structures that according to

Table 4 Infracolic peritoneum: visceral area ($n = 10$)

	Surface area (cm^2)		Percentage (100% total peritoneal area)		Dif CV%
	Mean ± SE	CV%	Mean ± SE	CV%	
Mesentery	3,847.70 ± 431.17	35.44	26.23 ± 1.56	18.78	16.65
Jejunum–ileum	1,845.28 ± 145.73	24.97	12.98 ± 0.90	21.94	3.04
Greater omentum	949.98 ± 112.29	37.38	6.59 ± 0.72	34.38	3.00
Sigmoid colon	467.04 ± 73.08	49.48	3.17 ± 0.34	34.35	15.14
Transverse colon	437.14 ± 47.66	34.48	3.04 ± 0.21	22.31	12.16
Transverse mesocolon: inferior layer	287.00 ± 32.11	35.37	2.02 ± 0.23	35.74	−0.37
Caecum v. appendix ascending colon	256.36 ± 30.98	38.21	1.84 ± 0.24	41.76	−3.55
Sigmoid mesocolon	218.86 ± 32.51	46.97	1.53 ± 0.22	44.79	2.18
Uterus and broad ligaments	170.38 ± 23.23	43.12	1.18 ± 0.15	39.44	3.68
Rectum	99.09 ± 13.85	44.21	0.70 ± 0.10	46.76	−2.55
Descending colon	77.18 ± 8.49	34.78	0.54 ± 0.05	27.36	7.42
Urinary bladder	57.55 ± 8.14	44.72	0.40 ± 0.06	44.50	0.22
Total	8,713.55 ± 722.71	26.23	60.22 ± 1.63	8.56	17.67

Table 5 Infracolic peritoneum: parietal area ($n = 10$)

	Surface area (cm^2)		Percentage (100% total peritoneal area)		Dif CV%
	Mean ± SE	CV%	Mean ± SE	CV%	
Right antero-lateral infraumbilical wall	327.76 ± 34.02	32.83	2.31 ± 0.23	31.76	1.07
Left antero-lateral infraumbilical wall	324.58 ± 26.24	25.57	2.31 ± 0.19	26.63	−1.07
Left dorsal infracolic parietal wall	205.00 ± 22.56	34.81	1.44 ± 0.14	31.01	3.80
Right dorsal infracolic parietal wall	161.00 ± 21.14	41.52	1.14 ± 0.15	42.11	−0.59
Left lateral pelvic wall	52.85 ± 7.23	43.26	0.39 ± 0.07	53.18	−9.92
Right lateral pelvic wall	51.44 ± 6.43	39.53	0.38 ± 0.06	46.20	−6.67
Total	1,122.62 ± 55.91	15.75	7.97 ± 0.45	17.85	−2.10

Table 6 Total peritoneal surface area: measured and calculated by formulas ($n = 10$)

Measured in this study	1.43 ± 0.08
DuBois and DuBois formula (1916) [6]	1.50 ± 0,08
Boyd Formula (1935) [1]	1.48 ± 0,10
Gehan and George formula (1970) [12]	1.49 ± 0,09
Haycock et al. formula (1978) [15]	1.47 ± 0,10
Mosteller formula (1987) [20]	1.48 ± 0,09

Values are expressed as mean ± SE (m^2)

the literature are covered by serosa. The supra- and infracolic surfaces and their corresponding visceral and parietal portions were also determined, thus summing these partial values. Finally, the total peritoneal surface area was obtained.

The values of total peritoneal surface area that we obtained (14,323.62 ± 824.37 cm^2) are significantly greater ($P < 0.01$ ANOVA) than those obtained by Esperanca and Collins [8] (10,379.00 ± 453.57 cm^2) and Rubin et al. [25] (7,791 ± 441 cm^2). This could be due to the differences in the cadavers used and/or the method used. In order to study this, we have done the following statistical analyses.

Differences observed in the cadavers used in this paper and in other papers

Considering the individual data shown in the tables published by Esperanca and Collins [8] whose mean values of the total peritoneal surface in a group of six cadavers was 10,379 cm^2, we calculated that the SE of said mean is 453.57 cm^2. According to the data of Rubin et al. [25], the peritoneal surface area corresponding to the eight cadavers (four males and four females) was 7,791.00 ± 441.00 cm^2.

The peritoneal surface area of the four female cadavers of said group (7,430.00 ± 523.06 cm^2) does not significantly differ from the male cadavers.

The body weights in our study (49.51 ± 6.08 kg) do not significantly differ from those of the group of six cadavers of Esperanca and Collins [8] (58.25 ± 3.36 kg), but they are significantly lower ($P < 0.01$) than the ones obtained in the group of eight cases, four males and four females, of Rubin et al. [25] (76.80 ± 7.10 kg). The female cadavers of these authors had even a bigger body weight than the body weight of our cadavers (72.90 ± 11.02 kg; $P < 0.05$; ANOVA).

There is an important correspondence between the peritoneal surface measured and the body weight, as shown in the positive and statistically significant Pearson's correlation coefficient (0.793 $P < 0.04$) (Table 7).

This indicates proportionality in the variation of one of the variables with relation to the other one although one or both of them suffer small variations.

However, the corresponding regression line, peritoneal surface (m^2) = 0.8987 m^2 + 0.0107 m^2/kg × kg (of body weight), shows a relatively low slope. This indicates that in the studied sample, body weight variations slightly affect the peritoneal surface area. This is due to the fact that in our sample the values of the weights of the cadavers were more heterogeneous than the values of the measured corresponding peritoneal surfaces. Thus, the coefficient of the percentage variation of the measured peritoneal surfaces mean (18.20%) is inferior to half of the coefficient of percentage variation corresponding to body weights mean (38.82%).

It is assumed that the greater average of the total peritoneal area obtained in this study with relation to that obtained by the above-mentioned authors would not be due to sex or body weight since these are similar or superior to ours.

Study of the differences observed in the methods used in this paper and in other papers

The above-mentioned comparisons suggest that the significant differences obtained between our data and those obtained from these authors could be a consequence of the use of fresh eviscerated material that though it facilitates the maneuvers it is more operator-dependent. Esperanca

Table 7 Pearson's correlation coefficients among weight, peritoneal surface measured and calculated according to DuBois and DuBois, Boyd, Gehan and George, Haycock et al. and Mosteller ($n = 10$)

	Weight	Measured surface area	DuBois and DuBois [6]	Boyd [1]	Gehan and George [12]	Haycock et al. [15]
Measured surface area (this study)	0.793					
DuBois and DuBois (1916) [6]	0.966	0.674				
Boyd (1935) [1]	0.993	0.753	0.988			
Gehan and George (1970) [12]	0.989	0.736	0.993	0.999		
Haycock et al.(1978) [15]	0.992	0.744	0.990	0.999	0.999	
Mosteller (1987) [20]	0.986	0.728	0.995	0.998	0.999	0.999

$P < 0.04$ for all values

and Collins [8] reported that "approximations were used, and the area, therefore, was probably underestimated". Rubin et al. [25] stated that as regards the method they had used "care was taken not to overstretch these tissues".

Supra- and infra-mesocolic parietal and visceral peritoneum

In our studies, the percentage values corresponding to the visceral and parietal total areas (81.89 ± 0.99 and 18.11 ± 0.99%, respectively) were similar to the values obtained by Rubin et al. (26) (81.27 and 18.73%) and to the ones obtained by Pawlaczyk et al. [22] (81.9 and 18.1%), but are different from those obtained by Esperanca and Collins [8] (91.96 and 8.04%).

We have not found in the literature values about the supra- and infra-colic peritoneal surface areas, nor about the parietal and visceral corresponding portions. The supracolic surface was of 4,487.46 ± 196.21 cm^2 (31.79 ± 1.50%) and the infracolic surface was of 9,836.16 ± 732.67 cm^2 (68.21 ± 1.50%). The visceral peritoneum in the infracolic region is about 12 times bigger than parietal peritoneum.

A relevant result of this paper is that the surface area of the parietal peritoneum is more than the double in the supracolic region than in the infracolic region (68.56 and 31.44%, respectively). This mainly occurs at the expense of the diaphragmatic peritoneum. This result can be of interest, since some papers describe the functional differences between the visceral and parietal peritoneum [2, 27, 30].

Posterior parietal peritoneum is visceral or parietal?

The posterior parietal peritoneum deserves a special consideration. In the papers about this subject, this peritoneum portion is considered a parietal peritoneum [8, 14, 22, 23, 25, 26]. That is the reason why it is included as parietal peritoneum in this paper. Nevertheless, the greater part of it does not derive from the primitive parietal celoma but from the dorsal mesentery of the fetus.

During the last period of the fetal life by means of the coalescence processes typical of human beings these mesos are adhered to primitive parietal peritoneum. These mesos keep in the postnatal life their vascular systems at a visceral level. They correspond in the infracolic region to the ascending and descending mesocolon constituting the posterior walls of right and left mesenterocolic spaces (Table 5) and in the supracolic region to the suprapancreatic section of the lesser sac posterior wall (Table 3). In experimental animals, these coalescences do not occur that is why the peritoneum portions remain visceral and the dorsal wall keeps the parietal peritoneum derived from the primitive celoma cavity.

This would explain why some papers considered the posterior parietal peritoneum as the psoas peritoneum. This could be justified in experimental animals in which the psoas is visible from the peritoneal cavity because there are no coalescences and the "lame vasculaire de l̈abdomen" of Ombredanne [21] is very slender.

These differences between the animal and the human peritoneum should be taken into account. In this sense, Pawlaczyk et al. [22] have demonstrated that the percentages of the peritoneal surface of each organ with reference to the total number differ between humans and experimental animals. They said "Presented results show that interspecies variation in the topography of the peritoneum should be taken into account when the results from experimental studies done on animals are extrapolated to humans".

Measurement of 40 peritoneal areas: clinical and surgical significance

Esperanca and Collins [8] considered for the measurement of the total peritoneal surface only nine areas (liver, stomach, spleen, intestine, mesentery, omentum, diaphragm, anterior abdominal wall, and pelvic organs). Rubin et al. [25] considered seven areas (liver, stomach, small and large intestine, diaphragm, and parietal-psoas

wall) and Pawlaczyk et al. [22] six areas (liver, stomach, spleen, intestine–mesentery–omentum, diaphragm and abdominal posterior-anterior-psoas wall).

As can be observed, there is no uniformity in the papers with regards to the structures that are measured. It is difficult to compare them. At the same time, it is not possible to establish to which structure some organs, mesos, ligaments or walls that do not appear in the tables have been added.

In this paper, 40 areas corresponding to each and all surfaces covered by the peritoneum according to Poirier and Charpy [23], Testut and Latarjet [26] and Gray [14] were measured.

We will be able to do the following:

1. Group them according to different criteria or needs.
2. Quantify the involvement percentages of the serosa in clinical practice or in surgery.

Total peritoneal surface area estimated by formulas in clinical practice

Pawlaczyk et al. [22] in eviscerated and fresh human cadavers determined that the total peritoneal surface area only represented a 75.9 ± 19.9% of the surface area estimated by DuBois and DuBois formula [6]. The peritoneal surface area measured in this study in non-eviscerated cadavers represents more than 96% of the one estimated by the above-mentioned formulas [1, 6, 12, 15, 20].

This study shows that the total peritoneal area can be appropriately calculated by the formulas originally created to estimate the body surface. Although this concept of concordance between the peritoneal and body surface areas are generally accepted in clinical practice, there are no previous papers that support it. On the other hand, if the formulas that allow to appropriately estimate the patient's total peritoneal area are available and if the data from the percentage contribution of the peritoneum to each structure are also available, we will be able to estimate the absolute value of the involved peritoneal surface in each patient.

In peritoneal dialysis, the formulas for calculating the peritoneal surface area are used in clinical practice based on dialysis adequacy for each patient and in research following theoretical models.

Other clinical and surgical applications of the results

There have been recently important advances in peritoneal diseases. In the past, peritoneal surface malignancy was considered an incurable disease. New diagnostic tools and therapies have shown an improved survival in selected patients with these diseases [4, 11, 17, 28]. Yan et al. [28] in peritoneal surface malignancy, and Lamme et al. [18] in peritonitis suggest standardization of the treatment protocols. In this regard, we consider that the present paper is a contribution to this area, since the exact quantification of the involved peritoneal area may be useful crucial for both therapies and for diagnosis and prognosis as well.

The values shown in this paper would provide non-existing information for basic anatomy and would contribute either to the study of pathologies involving the peritoneum or to their diagnosis and therapies.

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