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Review article

Bioelectrical impedance analysis; a new method to evaluate lymphoedema, fluid status, and tissue damage after gynaecological surgery - A systematic review

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ABSTRACT

The aim of this descriptive review is to summarise the current knowledge of non-invasive bioelectrical impedance analysis (BIA) used with gynaecological surgical patients in regard to postoperative development of lymphoedema and determination of perioperative fluid balance, and as a prognostic factor in cancer mortality and a predictor of postoperative complications.

The databases PubMed, MEDLINE, Scopus Web of Science, the Cochrane Library, and reference lists of selected articles were searched for relevant articles published during the period January 2008–April 2018. Only papers published in English were retrieved. Thirty-seven articles were evaluated. Where gynaecological studies were lacking, studies with a study population from neighbouring clinical fields were used instead.

Studies on the clinical use of BIA with gynaecological surgical patients were divided into three categories: the postoperative development of lower limb lymphoedema (n = 7), perioperative hydration measuring (n = 3), and the BIA parameter phase angle as a prognostic factor in cancer survival and as predictive for postoperative complications (n = 6). Of these 16 studies only three used a pure gynaecological study population. Three different methods of BIA were used in these articles: single frequency-BIA, multifrequency-BIA and bioimpedance spectroscopy. BIA was found to detect lymphoedema with a sensitivity of 73% and a specificity of 84%. Studies indicated that BIA was able to detect lower limb lymphoedema at an early stage even before it became clinically detectable. During postoperative hydration measurements, an increase in extracellular fluid volume and extracellular fluid volume in relation to total body fluid volume, as well as a decrease in phase angle, were associated with higher frequencies of postoperative complications. Moreover, low values for the phase angle have been associated with increased mortality in cancer patients. However, the number of studies in this field was limited.

From our review, BIA seems to be a useful tool for use in the clinical setting of the gynaecological surgical patient. The theoretical approach of using bioelectrical impedance values to measure the fluid distribution in the body compartments offers wide opportunities in the clinical setting. However, so far, all studies have set up cut-off limits within the study population, and reference values for a general population need to be defined. There are also rather few studies on a gynaecological study population. Hence, there is a need for further studies within gynaecological surgery focusing on early detection of lower limb lymphoedema, perioperative fluid balance, and postoperative complications in order to establish the value of BIA in clinical praxis.

Abbreviations: BCM, body cell mass; BIA, bioelectrical impedance analysis; BIS, bioelectrical impedance spectroscopy; C, capacitance; CLI, capillary leak index; ECV, extracellular fluid volume; FFM, fat free mass; FFMI, fat free mass index; FM, fat mass; FMI, fat mass index; HGS, hand grip strength; ICV, intracellular fluid volume; LLL, lower limb lymphoedema; LO, lymphoedema; MF-BIA, multifrequency BIA; NRI, nutrition risk index; NRS, nutrition risk score; NSCLC, non-small cell lung cancer; PEF, peak expiratory flow; PhA, phase angle; R, resistance; SCCHN, squamous cell carcinoma head/neck; SD, standard deviation; SF-BIA, single frequency BIA; SGA, subjective global assessment; SPhA, standardised phase angle; TBV, total body water; Xc, reactance; Z, impedance.

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Introduction

Postoperative recovery without complications and long-term adverse side effects is the preference of all patients and the health care providers. However, for many reasons this goal is not always achievable, but substantial measures should be taken to minimise the risks for peri- and postoperative complications and adverse side effects of the treatment. Although many risk factors for postoperative complications and long-term adverse side effects are known, there is still a need for simple methods that, perioperatively, can predict and thus make it possible to prevent or restrict the development of these unwanted qualities.

During the past two decades, bioelectrical impedance analysis (BIA) has become a useful tool in clinical research. As a non-invasive method, it provides an estimation of total body fluid volume (TBV) expressed as fat-free mass (FFM). Through its geometrically based algorithm, BIA gives information on extracellular fluid volume (ECV) and intracellular fluid volume (ICV).

Body composition and hydration status contain valuable information about the patients' well-being as several medical conditions are accompanied by changes in TBV, body cell mass (BCM), fat mass (FM), FFM, ECV and ICV.

In this descriptive systematic review, we aimed to summarise the contemporary evidence of use of BIA in gynaecological surgical patients in studies published between 2008 and 2018. In particular, we highlighted the use of BIA for detection and prediction of lymphoedema and its use perioperatively for prediction of postoperative recovery. Where gynaecological studies have yet to be conducted in this field, we intended to give a theoretical reasoning regarding how the BIA method could be applicable in this patient category.

Material and methods

The PubMed, Scopus, Web of Science, MEDLINE, the Cochrane Library and Google Scholar databases were searched for articles published during the period January 2008–April 2018. The reference lists in all identified relevant articles and reviews were searched for additional published studies concerning the topic of bioelectrical impedance.

Studies were included based on the following criteria: 1) studies with whole body bioelectrical impedance analysis, 2) an adult study population, 3) covering gynaecological patients and using the bioelectrical impedance method, 4) a gynaecological study population or a clinical setting that can be applied to the gynaecological patient.

The search terms used included: bioelectrical impedance analysis, bioelectrical analysis, BIA, BIS, BIVA, MF-BIA, phase angle, fluids, electrolytes, hydration, dehydration, overhydration, hypohydration, sodium, hypernatraemia, female body composition, extracellular volume, intracellular volume, ECV, ICV, intracellular fluid, extracellular fluid, perioperative patient, perioperative gynaecological patient, gynaecological cancer, gynaecological surgery, operative hysteroscopy, lymphoedema, lower limb lymphoedema, lymphatic overload, lower abdomen surgery, postoperative nausea and vomiting, postoperative recovery, oxidative stress. AND/OR was used between the different search terms.

Where no gynaecological studies were found, articles covering abdominal, urological or breast surgery/cancer were used instead and a theoretical reasoning was used to apply this to the gynaecological settings. Only papers published in English were included in the review. Articles covering case reports, paediatric study populations, or articles which did not declare which BIA tool

Table 1
Different bioelectrical impedance techniques used in studies between 2008–2018. The common theory for all methods described in the table: An alternating current is applied, typically at the wrist and the ankle of the patient, and the response is measured as resistance at reactance. At low frequencies < 50 kHz the electrical current cannot penetrate cell membranes and therefore predict ECV.

Bioelectrical impedance measurements	Concept	Reference
SF-BIA: single frequency BIA	Typically use of 50 kHz. Where articles did not specify if they used single- or multifrequency, methods using frequency at only 50 kHz were categorized SF-BIA.	1–6
MF-BIA: multifrequency BIA	Typically use of 5, 50 and 100 kHz. Higher frequency > 50 kHz can penetrate cell membranes and be used to estimate ICV	7–9
BIS: Bioelectrical impedance spectroscopy	ECV and ICV are calculated using the Hanai and Cole model rather than regression equations to predict body composition. These models allows separation of fluid overload from the muscle mass. The term spectroscopy is used because BIS utilise a spectra of frequencies.	10–16

ECV: extra cellular volume; ICV: intra cellular volume.