LAPAROSCOPIC GYNECOLOGIC SURGERY WITH ATMOSPHERIC AIR AT LOW PNEUMOPERITONEUM COMPARED WITH CARBON DIOXIDE AT LOW AND STANDARD PNEUMOPERITONEUM: EFFECTS ON HEMODYNAMICS, INTRAOPERATIVE AND POSTOPERATIVE COMPLICATIONS

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Abstract. *Laparoscopy has become the standard approach for many benign gynecologic procedures and for selected oncologic interventions. However, the physiological cost of pneumoperitoneum remains significant. In clinical practice,*

carbon dioxide (CO_2) is used most often, and the standard pressure range is usually 12–15 mmHg; low pneumoperitoneum is generally considered to be below 10 mmHg. CO_2 remains the dominant gas because it is nonflammable, inexpensive, highly soluble, and rapidly eliminated through the lungs. At the same time, its absorption and the increase in intra-abdominal pressure are the main causes of some cardiopulmonary and pain-related complications.

Key words: *laparoscopy, gynecology, pneumoperitoneum, carbon dioxide, atmospheric air, hemodynamics, hypercapnia, postoperative pain*

Аннотация. *Лапароскопия стала стандартным методом для многих доброкачественных гинекологических процедур и для некоторых онкологических вмешательств. Однако физиологические издержки пневмоперитонеума остаются значительными. В клинической практике чаще всего используется углекислый газ (CO_2), а стандартный диапазон давления обычно составляет 12–15 мм рт. ст.; низкий пневмоперитонеум обычно считается таковым при давлении ниже 10 мм рт. ст. CO_2 остается доминирующим газом, поскольку он негорюч, недорог, хорошо растворим и быстро выводится через легкие. В то же время его абсорбция и повышение внутрибрюшного давления являются основными причинами некоторых сердечно-легочных и болевых осложнений.*

Ключевые слова: *лапароскопия, гинекология, пневмоперитонеум, углекислый газ, атмосферный воздух, гемодинамика, гиперкапния, послеоперационная боль*

Hemodynamic Effects. The principal physiological mechanism underlying the adverse effects of pneumoperitoneum is not only the gas itself, but also the increase in intra-abdominal pressure. As pressure rises, venous return decreases

because of compression of the inferior vena cava, systemic vascular resistance and afterload increase, and the result may be a reduction in stroke volume and cardiac output, especially in patients with limited cardiac reserve or under pronounced Trendelenburg positioning. In a randomized study, CO_2 pneumoperitoneum was associated with increased preload and afterload and a reduction in fractional shortening, although cardiac output did not change significantly in that work.

Reducing pneumoperitoneum pressure to low levels physiologically decreases the magnitude of these shifts. A recent meta-analysis of 85 randomized studies involving 7,349 patients showed that low IAP (<10 mmHg) reduces minor postoperative complications, pain, postoperative nausea and vomiting (PONV), and hospital stay duration, without increasing the risk of intraoperative complications. Although this analysis was not limited to gynecology, its physiological conclusion is highly relevant: the lower the pressure, the lower the cardiopulmonary load, but the greater the dependence on muscle relaxation quality, patient positioning, and surgical experience.

Low Pressure in Gynecologic Laparoscopy: Benefits and Limitations. In gynecologic laparoscopy specifically, the evidence base for low-pressure strategy is heterogeneous. An early systematic review of gynecologic procedures concluded that low pressures could not be recommended on a general basis: the benefit in pain reduction was minimal, while the quality of the operative field was impaired. A later 2021 review confirmed the same tendency: low pressure did not convincingly reduce pain at 6 and 24 hours, and visualization quality was significantly worse more often. This is an important point at the PhD level of interpretation: the physiological advantage of low pressure does not always translate into a clinical advantage if the technical feasibility of the procedure is compromised.

Nevertheless, individual randomized studies have shown a more favorable picture. In a prospective randomized study of laparoscopic hysterectomy, low pressure was safe and feasible and also reduced shoulder-tip pain. In another randomized study in women undergoing gynecologic laparoscopic surgery, pain was lower with low pressure than with standard and high pressure, but this came at the cost of longer operative time and greater blood loss. Therefore, in gynecology, low pressure may be considered a method to improve postoperative comfort, but only if adequate exposure is preserved and technical compromises are avoided.

Atmospheric Air at Low Pneumoperitoneum. The use of atmospheric air as the insufflation gas is much less studied than CO_2. In the Cochrane update on gases used to create pneumoperitoneum, only one trial series involved room air, including 146 participants: no serious cardiopulmonary complications or severe adverse events were observed in either the air or CO_2 groups; pain during the first postoperative day was slightly lower with air, but the difference of about 1 cm on the VAS was not considered clinically meaningful. A potential reduction in cost was also reported, but the evidence for this effect remained uncertain.

In gynecology, the data on room air are even more limited. In a clinical study of diagnostic laparoscopy, CO_2 provided better overall results, while room air remained “safe, inexpensive, and accessible,” which is especially important in low-resource health systems. At the same time, the literature emphasizes that the safety of atmospheric air as a routine alternative to CO_2 has not been established, and the risk of air embolism remains a major argument against widespread implementation. Therefore, room air should be interpreted not as an established standard technique, but as a potentially useful yet insufficiently validated option for selected situations, particularly in resource-limited settings and for diagnostic rather than complex reconstructive procedures.

Intraoperative and Postoperative Complications. The key difference between gases and pressure levels concerns not only pain, but also the complication profile. For CO_2, the best-known risks are hypercapnia, acidosis, hemodynamic changes, and rare but potentially fatal CO_2 embolism. Although the high solubility of CO_2 makes embolism less likely than with less soluble gases, it does not eliminate the risk entirely. For room air, the theoretical concern over air embolism is more serious; therefore, despite its technical simplicity, this option has not become widely used in gynecologic operating rooms.

Regarding low pressure, the overall evidence suggests a reduction in minor postoperative complications, pain, and PONV without an increase in intraoperative complications in general laparoscopic populations. However, gynecologic reviews show that the technical cost of low pressure may appear as worse visualization, longer operative duration, and, in some studies, increased blood loss. Consequently, in gynecologic laparoscopy, the optimal strategy is not a simplistic "the lower the pressure, the better" approach. Pressure should be minimized but still sufficient for safe dissection, especially in complex pelvic procedures, in severe obesity, in the presence of adhesions, and during prolonged Trendelenburg positioning.

Conclusion. From the standpoint of current evidence, the best compromise in gynecologic laparoscopy remains CO_2 at low rather than standard pressure, provided the surgical field remains adequate. Low pressure can indeed reduce pain and some postoperative complaints and may also lower the incidence of minor complications; however, its benefits are moderate and not universal. Atmospheric air at low pneumoperitoneum is an interesting alternative for limited-resource settings, but its evidence base is extremely weak and its safety has not been confirmed to a degree sufficient for routine use. For a PhD-level conclusion, the

statement should be precise: room air is an experimental and organizational alternative, whereas low-pressure CO_2 is a clinically supported but selectively applicable strategy.

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