EDITORIAL

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Illuminating the surgical field: the expanding role of Indocyanine Green (ICG) in gynaecological surgery

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Innovation in gynaecological surgery has always been driven by one fundamental aim: to improve patient safety while enhancing surgical precision. From the introduction of laparoscopy to the refinement of robotic platforms, each technological advance has sought to minimise morbidity and maximise clarity within the operative field. In recent years, fluorescence-guided surgery using indocyanine green (ICG) has emerged as a powerful adjunct in this evolution.[1] What was once largely confined to oncological sentinel lymph node mapping is now finding a meaningful place in benign gynaecology.[2-4] The recent review in Facts, Views & Vision in ObGyn[5] provides a timely and comprehensive appraisal of this transition, highlighting both the promise and the practical considerations of incorporating ICG into everyday gynaecological practice.

ICG is a water soluble tricarbocyanine dye that fluoresces in the near-infrared (NIR) spectrum when excited by appropriate imaging systems.[1] ICG has a well-established safety profile and rapid hepatic clearance, it offers surgeons real time visualisation of vascular perfusion and anatomical structures that may otherwise remain indistinct under white light. Its application in gynaecology has expanded steadily, propelled by improvements in NIR-equipped laparoscopic and robotic platforms.[4] What distinguishes ICG from many other surgical adjuncts is its immediacy by transforming invisible physiological information into visible guidance at the point of care.

In benign gynaecological surgery, the prevention of iatrogenic injury remains paramount. Ureteric injury during hysterectomy or deep endometriosis surgery, though uncommon, carries significant morbidity and medicolegal consequence. Traditional preventive strategies include meticulous dissection, identification under direct vision, and, in selected cases, pre-operative stenting. However, these approaches are not infallible, particularly in the context of distorted pelvic anatomy. ICG instilled via ureteric catheters to facilitate dynamic ureteric visualisation in real time is an exciting alternative.[3] The capacity to delineate ureteric course under NIR imaging may not only reduce the incidence of injury but also shorten operative time otherwise spent on extensive dissection solely for identification.[2,3,5]

Currently, ICG for ureteric visualisation still requires cystoscopy and cannulation of the ureteric orifices to deliver the dye. This makes its invasiveness comparable to temporary intraoperative ureteric catheterisation with Pollack catheters, as it also

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involves cystoscopic placement of ureteric catheters and removal.[6] Ideally, ureteric identification would not require cystoscopy at all. An intravenously administered fluorescent agent that selectively highlights the ureters throughout surgery would represent a major advance, providing continuous visualisation without cannulation. While such agents are under investigation, none are yet validated for routine use. A safe, reliable, and non-invasive method therefore remains an important unmet need, particularly in complex gynaecological surgery where ureteric injury risk is highest.

Beyond ureteric mapping, fluorescence imaging has shown value in assessing tissue perfusion during complex pelvic procedures. In cases requiring bowel resection for severe endometriosis, ensuring adequate vascular supply to an anastomosis is critical to reducing the risk of leak. While clinical judgement and visual cues have long guided surgeons, ICG provides an objective adjunct to confirm perfusion adequacy.[7] The ability to visualise perfusion gradients may influence resection margins and intraoperative decision making, potentially reducing postoperative complications. Importantly, this application bridges benign and oncological practice, underscoring how technological advances often transcend subspecialty boundaries.[1]

Endometriosis surgery represents another domain where ICG may enhance operative precision.[8] Deep infiltrating endometriosis frequently distorts normal anatomy, obscuring planes and vital structures. Although white light laparoscopy remains the standard, fluorescence imaging may assist in differentiating vascularised endometriotic lesions from surrounding fibrotic tissue.[7] While current evidence is heterogeneous and largely observational, early reports suggest that ICG may aid in lesion detection and in confirming adequate perfusion after excision. However, distinguishing between improved visualisation and improved clinical outcomes remains essential, and ongoing research is critical to clarifying clinical benefit.

The utility of ICG also extends to bladder endometriosis and multidisciplinary collaboration.[9] Cystoscopic administration can demarcate bladder nodules prior to laparoscopic excision, offering a clear visual boundary between diseased and healthy tissue. In collaborative settings, this shared fluorescence guidance may enhance communication and operative planning. The integration of gynaecological and urological expertise is increasingly important in complex pelvic surgery, and ICG may serve as a practical tool to facilitate this cooperation.

Despite these promising applications, several challenges must be addressed before ICG can be considered standard of care in benign gynaecology. There is a lack of universally accepted protocols regarding dosing, timing, and route of administration. Intravenous bolus doses vary across studies, and the optimal concentration for ureteric or bladder instillation remains under investigation. Without standardisation, reproducibility and comparison of outcomes become difficult.

Until recently, most studies have been observational or proof of concept rather than adequately powered comparative trials. This evidence gap has hindered definitive conclusions on clinical outcomes. Addressing this, the ICE trial[10] (ICG vs. conventional ureteric stenting in endometriosis surgery) represents one of the first randomised feasibility studies directly comparing ICG guided ureteric identification with traditional stenting in deep endometriosis surgery. Funded by the NIHR's Research for Patient Benefit programme and recruiting across UK sites including Birmingham Women's and Children's NHS and University Hospitals of North Midlands, this pilot trial aims to evaluate whether ICG can reduce operative time, post-operative pain, and stent-related morbidity compared with conventional stent methods.

The ICE trial builds on the recognition that while ureteric stenting has been a longstanding protective strategy, it is not without drawbacks, including post-operative discomfort and urinary symptoms. By using a small catheter to deliver ICG dye into the ureters, surgeons can visualise ureteral anatomy with NIR imaging, potentially reducing reliance on stents and improving patient experience without compromising safety.

Early insights from this work are expected to inform larger, multicentre trials and could establish a new evidence base for fluorescence guidance in benign gynaecological practice. The ICE trial exemplifies the type of comparative research needed to move beyond feasibility and towards evidence-based adoption, addressing a critical knowledge gap.

Cost and accessibility represent additional considerations. NIRcapable imaging systems are increasingly common in tertiary centres but may not be universally available. The financial implications of acquiring and maintaining such platforms, along with the cost of consumables, must be balanced against potential reductions in complication related expenditure. A thorough cost effectiveness analysis will be important in informing policy and

procurement decisions, especially within publicly funded healthcare systems.

Fluorescence imaging introduces a new visual modality into surgical practice. Surgeons must become proficient not only in the technical aspects of dye administration but also in the interpretation of fluorescence patterns. Over reliance without critical judgement could be as problematic as underutilisation. Structured training modules and inclusion in advanced laparoscopic curricula may support safe and effective adoption.

Ethical considerations further shape the discourse. Patients should be counselled regarding the use of ICG, including its rare but potential allergic reactions. Transparency about the evolving evidence base is essential. As with any adjunct technology, shared decision-making grounded in accurate information preserves patient autonomy and trust.

Looking ahead, the integration of fluorescence imaging with emerging technologies such as artificial intelligence and augmented reality offers intriguing possibilities. Real time quantitative perfusion analysis or automated ureteric tracking may further enhance the objectivity of intraoperative assessment. While these developments remain largely conceptual, they underscore the trajectory toward increasingly data driven surgery.

The broader question, however, is not merely whether ICG works, but how it reshapes surgical philosophy. Fluorescence guidance represents a shift from reliance on static anatomical knowledge toward dynamic physiological visualisation. It aligns with a precision-medicine paradigm in which intraoperative decisions are informed by immediate, patient-specific information. In this sense, ICG is emblematic of a wider transformation in surgical practice.

ICG is not a fleeting innovation but a tool with tangible potential to enhance safety and precision in benign gynaecology. Yet its promise will only be realised through collaborative research, thoughtful implementation, and continued reflection on outcomes. As surgical platforms evolve and imaging capabilities expand, the responsibility rests with clinicians to ensure that technology serves patient welfare rather than novelty.

In illuminating anatomical structures and perfusion patterns, ICG quite literally brings light into the operative field. More importantly, it symbolises the illumination of surgical decision-making through innovation grounded in evidence. The challenge now lies in transforming fluorescence from an adjunct used selectively by enthusiasts into a standardised, evidence-based component of high quality gynaecological care. If this can be achieved, the glow of NIR imaging may offer not only clearer vision in theatre but also a brighter future for patient safety and surgical excellence.

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