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Use of fluorescence imaging during lymphatic surgery: A Delphi survey of experts worldwide

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ABSTRACT

Background: Fluorescence imaging with indocyanine green is increasingly used during lymphedema patient management. However, to date, no guidelines exist on when it should and should not be used or how it should be performed. Our objective was to have an international panel of experts identify areas of consensus and nonconsensus in current attitudes and practices in fluorescence imaging with indocyanine green use during lymphedema surgery patient management.
Methods: A 2-round Delphi study was conducted involving 18 experts in the use of fluorescence imaging during lymphatic surgery, all asked to vote on 49 statements on patient preparation and contraindications (n = 7 statements), indocyanine green dosing and administration (n = 10), fluorescence imaging uses and potential advantages (n = 16), and potential disadvantages and training needs (n = 16).
Results: Consensus ultimately was reached on 40/49 statements, including consistent consensus regarding the value of fluorescence imaging with indocyanine green in almost all facets of lymphedema patient management, including early detection, assessing disease extent, preoperative work-up, surgical planning, intraoperative guidance, monitoring short- and longer-term outcomes, quality control, and resident training. All experts felt it was very safe, while 94% felt it should be part of routine care and that

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indocyanine green was superior to colored dyes and ultrasound. Nonetheless, there also was consensus that limited high-quality evidence remains a barrier to its widespread use and that patients should still be provided with specific information and asked to sign specific consent for both fluorescence imaging and indocyanine green.

Conclusion: Fluorescence imaging with or without indocyanine green appears to have several roles in lymphedema prevention, diagnosis, assessment, and treatment.

Introduction

Lymphedema is a potentially catastrophic condition, estimated to affect somewhere from 140 to 250 million people worldwide.[1] Untreated, symptoms range from mild limb heaviness to disfiguring and often painful and/or disabling swelling.[1] Both primary and secondary forms of lymphedema exist—the former rare, occurring in only ~1 in 100,000 patients[2] and caused by congenital malformations that impair lymph drainage. Secondary lymphedema, which is much more common than its primary counterpart and, likely, markedly under-reported, stems from lymph vessel damage acquired in various ways, including cancer, cancer treatment, trauma, parasitic infections, and obesity.[3]

Neither primary nor secondary lymphedema, once fully established, is considered curable.[3,4] However, various nonsurgical and surgical techniques have been used to enhance sluggish lymphatic flow with variable success.[1] Such treatments include multifaceted decongestive physiotherapy[4,5] and surgical procedures like lymphaticovenular anastomosis (LVA),[6–8] vascularized lymph node transfer,[8,9] lymphatic vessel free flaps,[10] and vascularized omentum lymphatic transplantation.[11] Preventing secondary lymphedema from ever starting and recognizing it early enough to slow its progression and enhance its manageability are crucial to the management of many surgery patients, especially cancer patients who require extensive nodal resections involving either the axilla or groin.[4,10,12] As with treating established lymphedema, various nonsurgical and surgical techniques have been proposed to prevent the development or worsening of secondary lymphedema.[10,12,13]

Among the greatest challenges surgeons face when treating or trying to prevent lymphedema is finding the vessels, which are often difficult to locate because lymph fluid is generally clear and contains few cells.[14] In recent years, numerous articles have been published, including controlled trials, reporting the effectiveness of injecting indocyanine green (ICG) into vessels intraoperatively and observing them under near-infrared light for a variety of clinical purposes. Such purposes include identifying lymphatic vessels with high and low flow and locating collateral vessels in cancer patients requiring extensive node resections[15,16]; detecting early, asymptomatic decreases in lymphatic flow[4]; assessing lymphatic flow in patients receiving nonoperative therapy[17,18]; quantifying lymphatic contractility[19]; determining the need for surgical intervention[18]; guiding reparative surgical procedures like LVA; assessing lymph flow through anastomoses intraoperatively[20]; identifying lymphatic leaks[21,22]; and assessing short-, intermediate-, and long-term outcomes.[23] Despite its extensive use, however, because of its relative novelty, there are no published guidelines regarding when, why, and how to use fluorescence imaging (FI) for almost any of the numerous indications for which it is currently used. It is for this reason that, in February 2019, at a quarterly meeting of the advisory board of the International Society of Fluorescence Guided Surgery (ISFGS) in Frankfurt, Germany, the board decided to conduct a series of consensus surveys for the various indications where FI is used to aid in ultimately drafting procedure-specific consensus guidelines. The first of these studies to be initiated is presented herein. Its main objective was to identify the areas of consensus and nonconsensus in the use of FI during lymphedema surgery. More specifically, this survey primarily assessed (1) whether ICG fluorescence can be used to evaluate lymphedema; (2) how effective it is at various stages of lymphedema evolution and for what specific purposes; (3) when it should and should not be used; and (4) the technical performance of ICG fluorescence lymphography, in terms of ICG administration dose, route, and timing.

Methods

Study architecture

The present study was a 2-stage, 2-round Delphi survey, adhering to published guidelines and coordinated by an international, MD-PhD–level expert in survey design. Since its emergence among the military after World War II as a means of reaching consensus on handling of the Cold War, Delphi studies have achieved considerable credence as a way to identify areas of consensus and nonconsensus among experts across a wide variety of health- and non–health-related fields.

The first stage of our survey was conducted in Buenos Aires, Argentina, during a special session at the 27th International Congress of Lymphology in September 2019. At this session, 10 internationally known experts in the use of FI during lymphedema surgery participated in a 2-round Delphi survey. Because only 10 experts attended this meeting, and the study investigators had hoped for $\geq$15–20, a second-stage, an online (modified) Delphi survey was initiated a few months later, and all data from the in-person and online Delphi studies compiled.

Survey development

After the above-noted ISFGS advisory board meeting in Frankfurt, Germany,[24] e-mails were distributed to all advisory board members asking every member to provide a list of questions/issues they considered important pertaining to FI use during procedures within their surgical field. These suggestions then were screened and used to generate a series of Delphi surveys intended for distribution among experts within each specific surgical field. For the lymphedema Delphi study, the final survey consisted of 7 questions regarding each expert's surgical practice, followed by 49 statements to vote upon, divided into 4 modules: module 1, patient preparation and contraindications (n = 7 statements); module 2, ICG dosing and administration (n = 10); module 3, uses and potential advantages of using FI during lymphedema surgery (n = 16); and module 4, potential barriers and training issues (n = 16). Among these 49 statements, 34 had the binary response option agree/disagree and 15 multiple-choice options like selecting 1 of 4 ICG doses.

During survey design, several approaches were adopted to reduce the acquiescence bias risk that the survey instrument itself might influence responses via either the wording and/or order of its statements and/or response options. This entailed including statements favorable, unfavorable, and neutral to FI and varying the

order of response options, sometimes listing the most FI-agreeable option (eg, agree) first and sometimes last.

Expert recruitment and data collection

The following eligibility criteria were used to select experts: (1) coauthorship of ≥1 published clinical study examining FI use during lymphedema surgery; (2) or ≥10 years in surgical practice and 5 years using FI during lymphedema surgery. Survey participants also had to (3) be acknowledged as an international expert by the ISFGS advisory board, (4) be fluent in written English, (5) express willingness to participate, and (6) express willingness to review and provide comments on the manuscript before its submission for publication. The potential experts were identified by word of mouth and by reviewing all published studies on FI for lymphedema surgery to identify corresponding authors. This ultimately resulted in a list of 26 international experts spanning 5 continents (ie, North America, Latin America, Europe, Asia, and Oceana).

Stage 1

As stated earlier, 10 of these 26 experts attended the special session in Buenos Aires, Argentina, at which a 2-round, traditional Delphi survey was conducted. Voting was conducted electronically on voters' cell phones or any other handheld device, linked to the polling software Slido (Bratislava, Slovakia), with statements displayed on a large screen in PowerPoint (Microsoft Corp, Redmond, WA). Before voting on each statement commenced, the voters were permitted to ask questions of clarity only, with voting permitted only after all questions of clarity were answered and the moderator announced the start of voting. From then, voters had 30 seconds to vote before voting was blocked. Only statements for which consensus was not reached were re-presented in round 2, after which all voting was terminated. Immediately before voting on each statement in round 2, the results of round 1 were displayed for all voters to see.

Stage 2

Once the decision was made to seek further voters, an e-mail was sent to the 16 experts on our initial list of 26 who did not attend the special session in Buenos Aires, Argentina, asking them to participate in the survey and providing a link to the online survey application SurveyMonkey (Momentive, San Mateo, CA) with follow-up e-mails sent to all nonrespondents once weekly for 3 weeks, followed by an e-mail or telephone call from the primary project co-ordinator (F. Dip) to anyone who had not yet responded. For stage 2, round 1 was considered complete within 1 week of the above-noted telephone calls. At that point, round 1 data were compiled from stages 1 and 2 and analyzed to determine which statements had and had not consensus reached. As in stage 1, only statements for which adequate consensus was not reached were included in round 2, when the same e-mail, telephone, and data collection termination protocol used for round 1 was repeated. As in stage 1, for each statement in stage 2, round 2 voters were provided with the percentage of participants who had selected each response option in round 1.

Data analysis

The percentage of consensus was defined as agreement between responders, not agreement with any given statement, and was calculated as the number of voters choosing the most commonly selected response option divided by the total number of experts who voted on that particular statement, with ≥70% consensus considered "consensus reached." The percentage participation also was calculated for each statement, with ≥80% participation considered necessary for consensus/nonconsensus to be considered valid. Although the small numbers provided no opportunity to inferentially compare stage 1 and 2 voters, we nonetheless compared the overall level of consensus (ie, the proportion of statements for which consensus was reached) between the 2 stages and counted all statements, whereupon the majority selection between the 2 groups differed (ie, the majority in stage 1 selected 1 response option, whereas the majority in stage 2 selected another).

Also, given that round 2 was completed for stage 1 (Argentina in-person) before round 1 even could be initiated in stage 2 (online), there were 5 instances when compiling round 1 data from the 2 stages resulted in a statement on which consensus reached in stage 1 no longer satisfied our consensus criteria when data from the 2 stages were combined. To correct for this, simultaneously with participants in stage 2 being sent their round 2 surveys, all stage 1 participants were e-mailed a link to a supplementary round 2B survey containing these 5 statements, along with the compiled round 1 results, to have them vote on each of these 5 statements again. For each of these 5 statements, the earlier stage 1, round 2 results were replaced in analysis with the later round 2B results.

For quality control, all data were analyzed using both the SurveyMonkey intrinsic data-analysis tool and Windows Excel, version 16.0 (Microsoft Corp).

Table I
Practice characteristics of the voting experts

Practice characteristic	Number	Percentage
Region of practice ($N = 18$)		
Asia-Pacific	3	16.7
Europe	9	50.0
North America	2	11.1
Central and South America	4	22.2
Nature of practice ($N = 18$)		
Some university affiliation	15	83.3
Nonacademic	3	16.7
Area of surgery ($N = 18$)		
Plastic surgery	10	55.5
Oncology surgery	5	27.8
Lymph surgery	3	16.7
Years performing lymphatic surgery ($N = 18$), y		
<10	2	11.1
10–20	7	38.9
>20	9	50.0
Years performing fluorescence-guided surgery (N =18), y		
<5	5	27.8
5–10	6	33.3
>10	7	38.9
Fluorescence-guided procedures per month ($N = 17$)*		
<5	2	11.8
5–10	6	35.3
>10	9	52.9
Percentage of lymph surgeries using indocyanine green ($N = 18$)		
<50%	8	44.4
≥50%	10	55.6

* Question left blank by 1 respondent.

Results

Among the 18 survey participants, a majority ($n = 10$) practiced in Europe (Belgium = 4 and 1 each from France, Italy, Poland, Romania, Spain, and the United Kingdom), whereas 3 each came from Asia-Pacific (Japan = 2 and Australia =1) and Latin America (Brazil = 2 and Argentina = 1) and 2 from North America (USA = 2). The vast majority had university-affiliated practices. Among the experts were 10 plastic surgeons, 5 cancer surgeons, and 3 specializing in lymphatic surgery. Further panel characteristics are

Table II
Overall summary of results

	Number	Percentage
Total number of statements	49	
Consensus reached	40	81.6
No consensus reached	9	18.4
Consensus reached in first round*	34	85.0
Consensus reached in second round*	6	15.0
100% consensus reached*	4	10.0
90%–99% consensus reached*	7	17.5
80%–89% consensus reached*	17	42.5
70%–79% consensus reached*	12	30.0
Statements agreed with (total)	30	61.2
Statements disagreed with (total)	4	8.2
Statements agreed with (consensus)	29	59.2
Statements disagreed with (consensus)	2	4.1
Statements worded favorably to FI/ICG	22	44.9
Statements worded unfavorably to FI/ICG	11	22.4
Nonjudgmental statements	16	32.7
Average consensus	77.1%	
Minimum/maximum consensus	36.4%–100%	
Minimum when consensus reached*	70.6%	

FI, fluorescence imaging; *ICG*, indocyanine green.
* Percent among statements wherein consensus was reached.

summarized in Table I. Among the 8 nonparticipants, 3 were from North America (all USA), 3 from Europe (Belgium, Finland, and Italy), and 2 from Asia-Pacific (Australia and Japan).

Of the 49 statements on which the experts were asked to vote, 22 were worded in a way favorable to using FI, whereas 27 were worded either unfavorably or neutrally (Table II). A consensus of ≥70% was reached on 40 of the 49 statements, 34 in the first round and 6 in the second. Strong consensus (≥90%) was reached on 11 statements (100% for 4), whereas 17 achieved moderate (80.0%–89.9%) and 12 weaker (70.0%–79.9%) consensus.

Tables III through VI summarize results for each of the 49 statements. The overall level of consensus for module 1 (patient preparation and contraindications) was much higher (91.9%) than for any of the other 3 modules, with module 3 (potential uses and advantages) a distant second, at 77.4%, followed by module 4 (potential barriers and training issues), with 73.3%, and module 2 (ICG dosing and administration), with 72.8% consensus.

At least moderate-level consensus was achieved for each of the 7 statements on patient preparation and contraindications against using FI (Table III), including completely unanimous consensus on 3 statements, with 100% of the experts agreeing that intraoperative fluorescence guidance should be considered safe, but also that patients still should be provided with information specifically about FI and asked about any allergy to iodine preoperatively. In addition, 83.3% disagreed that ICG can be used subcutaneously in iodine-allergic patients.

Regarding ICG dose and administration (Table IV), consensus was reached that both when ICG is administered during the procedure and how long surgeons must wait after ICG administration before using near-infrared light are important, as is the concentration, but not the dose, of ICG (60% considered the actual dose of ICG important, whereas 33% voted that the level of importance is situation-dependent). There was strong consensus regarding the minimum effective dose to give to visualize lymph vessels and weak consensus regarding the optimum dose, but no consensus on the dose for sentinel lymph node (SLN) localization. For SLN localization, 0.2 mL (at 5 mg/mL = 1 mg) was the dose most commonly selected (by 40% of the experts), with 67.6% agreeing that the dose should be ≤0.5 mL (2.5 mg). There similarly was no consensus regarding how long surgeons should wait before performing the same lymphatic surgery procedure using ICG a second time; although, combining response options, 77.0% voted for a duration of ≥3 months.

Regarding FI uses and advantages (Table V), all areas of nonconsensus pertained to timing, including how long to wait after lymphatic surgery, how long to wait after SLN resection to perform follow-up ICG lymphography, and whether fluorescent lymphography should be performed before any radioisotope is given. Conversely, there was unanimous agreement that FI can be used to plan lymphatic treatment and strong consensus that it should be part of routine surgical practice. There also was consensus that FI was useful for virtually every listed indication, both diagnostic and therapeutic, including early detection of lymphedema in cancer patients, irrespective of whether they had or not had chemo- and/or radiotherapy; preoperative work-up; visualizing both lymph vessels and SLNs; treating and monitoring outcomes for lymphatic disorders; and quality control. There was 83% consensus that ICG use should be part of the algorithm for assessing patients for lymphedema.

When asked to compare ICG, colored dyes, and ultrasound in their effectiveness aiding visualization during lymphatic surgery, 94.4% selected ICG as best (Table VI). There again was consensus regarding the usefulness of FI for various general purposes, including strong consensus supporting its use visualizing lymphatic structures, enhancing patient outcomes, and training surgical residents. There also was consensus that nonsurgical residents should also learn about FI and that its noninvasiveness, ability to reduce complications, and low cost are advantages. On the other hand, barriers to its use include the need for repeat dosing, the limited availability of equipment and adequate training, and the lack of published high-quality data. Most, but just short of 70%, disagreed that failed fluorescence and inadequate nursing training administering ICG are limitations. No consensus was achieved on the number of cases needed for surgeons to overcome the learning curve, although, combining response options, 85% voted for >10 cases.

Comparing the 2 expert panels—those completing the survey in person and those completing it online—just 10 instances (out of 49 statements) were identified where consensus was reached in 1 panel and not the other. However, for only 1 statement did a majority on 1 panel vote for 1 response option whereas a majority in the other voted for another, and this pertained to how long surgeons should wait before repeating the same procedure using ICG (the majority in 1 group selecting 3 months and the other >3 months, with a clear majority in both groups believing that ≥3 months were necessary).

Discussion

An exponentially growing body of literature is reporting the value of intraoperative FI across a very broad range of surgical fields and scenarios,[25] including plastic[26–31] and vascular surgery,[32,33] largely for the purpose of assessing tissue perfusion. Similarly, its multidimensional value is steadily being revealed for early detection of lymphedema as well as its diagnostic confirmation, pretreatment planning, therapeutic management, and post-treatment outcomes monitoring among patients managed both surgically[1,6–13,15,18,34–47] and nonsurgically.[4,5,16,18,48,49] In 2015, the Australian Lymphedema Education Research and Treatment (ALERT) program adopted the use of FI with ICG, and now uses it for virtually all aspects of lymphedema patient care.[18] In 2019, the German-Speaking Society for Microsurgery of Peripheral Nerves and Vessels published consensus recommendations for lympho-reconstructive microsurgery for secondary lymphedema and concluded that that the use of FI with ICG during preplanning is “inevitable.”[50]

In a systematic review of the literature, published by Abbaci et al,[12] investigators analyzing 33 studies regarding the effectiveness of ICG imaging in breast cancer patients for the purposes of axillary reverse mapping, lymphography, and upper-limb

Table III
Module 1: patient preparation and contraindications to fluorescence imaging and/or indocyanine green

Statement	No. of votes	Response	No. of rounds	% Consensus
In general, the use of fluorescence-guidance during surgery should be considered very safe.	18	Agree	1	100.0
Patients undergoing a procedure using fluorescence technology should be provided specific information about it before undergoing the procedure.	18	Agree	1	100.0
Before being administered ICG, patients should be asked if they are allergic to iodine.	18	Agree	1	100.0
Patients undergoing a procedure using ICG should be provided specific information about the drug before undergoing the procedure	18	Agree	1	88.9
Patients undergoing a procedure using fluorescence technology should generally be asked to give informed written consent for it to be used.	18	Agree	1	83.3
Patients undergoing a procedure using ICG should generally be asked to give informed written consent for it to be used.	18	Agree	1	83.3
If a patient reports being allergic to iodine, ICG can still be used subcutaneously.	17	Disagree	1	82.4

ICG, indocyanine green.

Table IV
Module 2: indocyanine green dosing and administration

Statement	No. of votes	Response	No. of rounds	% Consensus
Consensus reached				
In general, the length of time one waits after administering ICG to view the anatomy under near-infrared light is important, unimportant, or depends on the situation.	17	Important	1	94.1
The minimum effective dose of ICG for fluorescence imaging for lymphatic vessel visualization is…	17	0.1–0.2 mL (2.5 mg/mL)	1	94.1
In general, the timing of ICG administration is important, unimportant, or depends on the situation.	17	Important	1	88.2
The maximum number of fluorescent lymphography procedures that should be performed annually in a patient to evaluate lymphedema progression is…	15	<10	2	86.7
It is important to repeat ICG lymphography after a surgical procedure.	15	Agree	2	73.3
The optimal dose of ICG to give to evaluate lymph vessels is…	15	0.2 mL (2.5 mg/mL)	2	73.3
In general, the concentration of ICG that is administered is important, unimportant, or depends on the situation.	18	Important	1	72.2
No consensus reached				
In general, the dose of ICG that is administered is important, important, unimportant, or depends on the situation.	15	Important	2	60.0
Before the same procedure is performed a second time with ICG, one should wait…	13	>3 mo	2	46.2
The optimal dose of ICG to give to evaluate lymph nodes is…	15	0.2 mL	2	40.0

ICG, indocyanine green.

Table V
Module 3: potential advantages and uses of fluorescence imaging with indocyanine green

Statement	No. of votes	Response	No. of rounds	% Consensus
Consensus reached				
ICG can be used to plan lymphatic treatment.	18	Agree	1	100.0
Fluorescence imaging, with and without ICG, should be part of routine surgical practice.	15	Agree	2	93.3
Fluorescence imaging, with and without ICG, is useful for surgical quality control.	17	Agree	1	88.2
ICG needs to be considered for the preoperative work-up of lymph surgery patients.	17	Agree	1	88.2
In general, fluorescence imaging is an important tool for the visualization of lymphatic vessels.	18	Agree	1	83.3
The use of ICG to evaluate lymphatic vessels should be included in the algorithm for assessing patients.	18	Agree	1	83.3
In general, fluorescence imaging is an important tool for the visualization of sentinel lymph nodes.	17	Agree	1	82.4
ICG is useful as a diagnostic tool to evaluate the treatment of lymphatic disorders.	17	Agree	1	82.4
ICG is important to detect early evidence of lymphedema after sentinel lymph node identification.	17	Agree	1	82.4
ICG is important to detect early lymphatic changes after sentinel lymph node identification in patients receiving chemo- or radiation therapy for cancer.	17	Agree	1	82.4
ICG should be used to evaluate syndromes associated with lymphatic dysfunction.	15	Agree	1	80.0
ICG is useful for following up the noninvasive treatment of lymphedema.	18	Agree	1	77.8
Considering the diagnosis and treatment of lymphatic disorders, it is important to perform fluorescent lymphography for… (diagnosis, treatment, or both).	17	Both	1	70.6
No consensus reached				
It is appropriate to perform ICG lymphography after surgery on the lymph vessels.	13	After 3 mo	2	53.8
Fluorescent lymphography should be performed before any radioisotope study to evaluate the lymphatic vessels.	14	Agree	2	50.0
Postoperatively, initial fluorescent lymphography after sentinel lymph node resection is appropriate at roughly…	15	>3 mo	2	40.0

ICG, indocyanine green.

Table VI
Module 4: potential barriers and training issues

Statement	No. of votes	Response	No. of rounds	% Consensus
Consensus reached				
Fluorescence imaging technology has the potential to significantly enhance patient outcomes.	17	Agree	1	94.1
The most effective visualization tool during lymphatic surgery is... (ICG, colored dyes, ultrasound)	17	ICG	1	94.1
Fluorescent lymphography is useful for training residents.	17	Agree	1	94.1
Increased visualization of lymphatic structures is an advantage of using fluorescent lymphography.	16	Agree	1	93.8
The noninvasiveness of the procedure is an advantage of using fluorescent lymphography.	16	Agree	1	87.5
The need for repeat dosing is one of the most common problems experienced during fluorescence imaging.	15	Disagree	1	80.0
Decreased risk of complications is an advantage of using fluorescent lymphography.	16	Agree	1	75.0
Equipment/technology unavailability is one of the most common problems experienced during fluorescence imaging.	16	Agree	1	75.0
Limited high-quality scientific data is one of the most common problems experienced during fluorescence imaging.	16	Agree	1	75.0
Unfamiliarity with the procedure is one of the most common problems experienced during fluorescence imaging.	16	Agree	1	75.0
Cost-effectiveness is an advantage of using fluorescent lymphography.	11	Agree	2	72.7
Exposure of physician trainees to fluorescent imaging should begin during… (medical school, residency).	11	Residency	2	72.7
Not just surgical residents but also residents in other nonsurgical fields should learn about fluorescence imaging.	11	Agree	1	72.7
No consensus reached				
Inadequate nurse training is one of the most common problems experienced during fluorescence imaging.	11	Disagree	2	63.6
Failure of fluorescence due to inadequate dosing or faulty technique is one of the most common problems experienced during fluorescence imaging.	11	Disagree	2	63.6
The number of cases needed to overcome the learning curve is…	13	11–25	2	38.5

ICG, indocyanine green.

supermicrosurgery concluded that, although high-quality evidence proving the efficacy of FI with ICG over standard clinical techniques remains inadequate, its potential as a real-time, multidimensional imaging technique not requiring a radiolabeled probe is great.

Our panel of 18 international experts arrived at much the same conclusion; consensus was reached that limited high-quality evidence remains a barrier to the widespread use of this technology and that patients should be given specific information about and asked to sign specific consent forms both for FI and ICG. On the other hand, there was consistent consensus regarding the value of FI and/or ICG for virtually every clinical scenario in which their use might be considered during lymphedema patient management, including preoperative work-up, surgical planning, visualizing both lymph vessels and SLNs intraoperatively, intraoperative surgical guidance, monitoring outcomes, quality control, and resident training. There also was near-unanimous consensus that FI with ICG use should be part of both routine practice and any algorithm assessing individuals for lymphatic disease and that FI with ICG is superior to either using colored dyes or ultrasound, and unanimous agreement that intraoperative FI should be considered "very safe."

Delphi studies have inescapable limitations, primarily due to their being opinion rather than data based. This article, for example, summarized the opinions of experts who all use FI in their practice and have an academic/clinical interest in fluorescence. As such, the results presented herein should not be used to replace well-designed clinical trials to ultimately determine whether a given patient management approach is effective. Such opinions nonetheless have numerous uses and advantages that even the most robustly designed randomized clinical trials lack. Among these advantages are the Delphi technique's ability to permit those most qualified to interpret the literature in their field to do so, especially when published data conflict, to provide their views regarding the patient management approach of interest's limitations and need for further development and validation, and to potentially provide detailed instructions in how to perform this new technique or technology. Among critics' concerns is the potential for bias, the assumption that expert panels inherently consist of like-minded individuals.

In the present study, the overall level of consensus achieved was, at 77.1%, far from 100%, suggesting that our results did not reflect a clique of like-minded individuals agreeing with each other. Consensus also was reached on numerous items agreeing on the limitations of FI, including the need for further supportive empirical data. We would argue that such findings indicate a well-selected panel of experts. We also had experts from 11 countries spanning 5 continents and a largely academic panel with extensive surgical experience, all meeting stringent expert selection criteria, who largely were identified through their publication history, rather than via personal contacts.

Hence, despite a clear need for further controlled trials to report the extent to which and ways in which FI, with or without ICG, is effective as a means to manage lymphedema patients, this relatively new technology appears to have several roles in lymphedema prevention, diagnosis, assessment, and treatment.

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Conflict of interest/Disclosure

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