



Title	Impact of the fundamental use of surgical energy certification on surgeons' behavior and awareness of safe use of energy devices : a cross-sectional survey research
Author(s)	Kondo, Akihiro; Nishihara, Yuichi; Sato, Miho; Bilgic, Elif; Watanabe, Yusuke
Citation	Surgical endoscopy and other interventional techniques, 37(1), 241-247 https://doi.org/10.1007/s00464-022-09468-4
Issue Date	2023-01-01
Doc URL	http://hdl.handle.net/2115/91063
Rights	This version of the article has been accepted for publication, after peer review (when applicable) and is subject to Springer Nature 's AM terms of use, but is not the Version of Record and does not reflect post-acceptance improvements, or any corrections. The Version of Record is available online at: http://dx.doi.org/10.1007/s00464-022-09468-4
Type	article (author version)
File Information	SEND-D-22-00143_R1.pdf



[Instructions for use](#)

1
2
3 **Impact of the Fundamental Use of Surgical Energy Certification on Surgeons'**

4
5
6 **Behavior and Awareness of Safe Use of Energy Devices: A Cross-Sectional Survey**

7
8
9 **Research**

10
11
12
13
14
15
16 **Running head:** Surgical Safety Behavior and Awareness

17
18
19
20
21
22 Akihiro Kondo, MD, PhD¹, Yuichi Nishihara, MD, PhD², Miho Sato, BA³, Elif Bilgic,
23
24
25 PhD⁴, Yusuke Watanabe, MD, PhD^{3, 5, 6, *}
26
27
28
29
30

31
32 ¹ Department of Gastroenterological Surgery, Faculty of Medicine, Kagawa University
33
34

35 ² Department of Surgery, Shinmatsudo Central General Hospital
36
37

38 ³ Clinical Research and Medical Innovation Center, Institute of Health Science
39
40

41 Innovation for Medical Care, Hokkaido University Hospital
42
43

44 ⁴ Department of Experimental Surgery, McGill University
45
46

47 ⁵ Center for Medical Device Development, Institute of Health Science Innovation for
48
49

50
51 Medical Care, Hokkaido University Hospital
52
53

54 ⁶ Department of Gastroenterological Surgery II, Hokkaido University Faculty of
55
56

57 Medicine
58
59
60
61
62
63
64
65

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

***Correspondence to:** Yusuke Watanabe, MD, PhD

Department of Gastroenterological Surgery II

Hokkaido University Faculty of Medicine

Kita 14 Nishi 7, Kita-ku, Sapporo 060-8638, Japan

Tel: +81-11-706-7931

E-mail: yusuke.watanabe@pop.med.hokudai.ac.jp

Funding: The authors report no funding for this study.

1
2
3 **Abstract**
4
5

6 **Background:** The Fundamental Use of Surgical Energy (FUSE) program was
7
8
9 established to educate surgeons and trainees to promote awareness and behaviors for the
10
11 safe use of surgical energy devices. Despite its implementation, the impact of FUSE
12
13 certification on surgeons' behavior and safety awareness regarding practice of energy
14
15
16 devices remains unclear. This study aimed to identify the perceived impact of FUSE
17
18
19 certification on surgeons' behavior and awareness regarding the safe use of surgical
20
21
22 energy devices.
23
24
25
26

27
28 **Methods:** We performed a descriptive cross-sectional survey study, using non
29
30 probabilistic purposive sampling, and distributed 22-item web-based questionnaires
31
32 among all 59 FUSE-certified surgeons in Japan, excluding operating room nurses and
33
34
35 medical students. The questionnaire items covered demographics, surgical techniques
36
37
38 using various energy devices, changes in behavior and safety awareness,
39
40
41 communication with colleagues about surgical energy devices, and educational
42
43
44 activities related to energy devices.
45
46
47
48

49
50 **Results:** Fifty-seven participants completed the questionnaire (response rate 96.6%).
51
52
53 Most surgeons (91.3%) could apply material learned from the FUSE program in
54
55
56 practice, especially material related to monopolar electrosurgery. Fifty-six surgeons
57
58
59
60
61
62
63
64
65

1
2
3 (98.3%) reported increased awareness of surgical safety, and 35 (61.5%) reported
4
5
6 increased communication with operating room personnel about the safe use of energy
7
8
9 devices. Moreover, 56 participants (98.3%) indicated a need for systematic education in
10
11
12 surgical energy, with participants recommending fellows (94.7% of participants
13
14
15 specified that fellows should participate in further education), residents (75.4%), and
16
17
18 attending surgeons (63.2%) as the target recipients of this training.
19
20

21
22 **Conclusions:** After FUSE certification, not only did surgeons' knowledge increase, but
23
24
25 their energy-related surgical techniques in practice also improved. Furthermore, FUSE-
26
27
28 certified surgeons felt that they were more aware of surgical-energy safety and were
29
30
31 dedicated to its promotion.
32
33

34
35
36
37
38 **Key Words:** Fundamental Use of Surgical Energy (FUSE), certification, energy device,
39
40
41 safe usage, surgeons' behavior, safety awareness
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

Introduction

Electrosurgery-related adverse events such as surgical burns, operating room (OR) fires, and unrecognized organ injuries can result in patient harm [1,2]. Therefore, surgeons should be well informed about the safe use of energy devices (e.g., monopolar electrosurgery, ultrasonically activated devices, or vessel sealing devices). However, recent data have shown that many surgeons, including those who are experienced, demonstrate knowledge gaps in the safe and effective use of energy devices [3,4]. To address this issue, the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) has established a web-based didactic curriculum, known as the Fundamental Use of Surgical Energy™ (FUSE) program [5]. In 2014, the FUSE program was introduced in Japan. The first hands-on seminar was held as a pre-congress workshop at the 27th annual meeting of the Japan Society for Endoscopic Surgery [6].

Previous studies have shown that a structured curriculum based on the FUSE program significantly increases surgical trainees' knowledge and self-perceived comfort with the safe use of electrosurgical devices, with retention after 3 months and 1 year [7,8]. Nonetheless, the impact of obtaining FUSE certification on surgeons' behavior in the OR and on changes in surgeons' safety awareness have not been investigated. Moreover, the extent to which institutions or communities have been influenced by

1
2
3 FUSE-certified surgeons in practice is unknown. Hence, the purpose of this study was
4
5
6 to explore the perceived impact of the FUSE program on surgeons' behavior and safety
7
8
9 awareness regarding the use of surgical energy devices.
10
11
12
13
14
15

16 **Materials and Methods**

17 18 19 Study Design and Population

20
21
22 We sent email invitations to each FUSE-certified surgeon in Japan (N = 59) through the
23
24
25 Japan Association for Surgical Education to participate in a cross-sectional survey in
26
27
28 March 2021. However, to adhere to the aim of investigating surgeons' behavior and
29
30
31 awareness, the OR nurses and medical students were excluded from this study.
32
33
34

35 Participants were asked to complete a web-based questionnaire developed using Google
36
37
38 Forms and were given 3 weeks to complete the questionnaire (responses were
39
40
41 anonymous). This study adhered to the Ethical Guidelines for Medical and Health
42
43
44 Research Involving Human Subjects in Japan [9]. Ethical approval by the institutional
45
46
47 review board of Kagawa University, Kagawa, Japan was exempted because this study
48
49
50 did not involve any patients, affect the health of participants, or use their personal
51
52
53 identification information. All participants provided written informed consent prior to
54
55
56
57 completing the survey.
58
59
60
61
62
63
64
65

1
2
3 Survey Design
4
5

6 The questionnaire had 22 items and was divided into the following sections:
7

8
9 demographics (4 items), surgeons' use of surgical techniques with various energy
10 devices (4 items rated on 5-point Likert scale including a free description item), changes
11
12 in surgeons' behavior and safety awareness (4 items rated on 5-point Likert scale
13 including a free description item), frequency of communication with colleagues about
14
15 electrosurgery-related topics (4 items rated on 5-point Likert scale), and educational
16
17 activities related to energy devices that the surgeons participated in or conducted (6
18
19 items rated using single-choice, multiple choice, and 5-point Likert scale, including a
20
21 free description item; Table 1). The questionnaire was developed by FUSE certified
22
23 surgeons (AK, YN), who were experienced in designing educational activities on
24
25 surgical energy devices; they listed potential items by exploring the degree of
26
27 application among FUSE-certified individuals. Finally, the questionnaire was drafted
28
29 through a discussion with surveyor/educational researcher (YW)—a SAGES FUSE
30
31 committee member. The questionnaire items were validated by beta testing them with
32
33 two FUSE-certified individuals. For scoring purposes, Likert-responses 1, 2, 3 were
34
35 considered negative, while Likert-responses 4 and 5 were considered positive. Free
36
37 description items required self-reported responses for the following: 1) contents that are
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

1
2
3 lacking in the FUSE program for clinical practice application, 2) content-changes
4
5
6 required for teaching usage of surgical energy devices, and 3) barriers in teaching the
7
8
9 FUSE program.
10

11 12 Statistical Analysis

13
14
15
16 The survey results were analyzed using descriptive statistics. Responses from
17
18
19 gastrointestinal surgeons and from physicians with other specialties were compared
20
21
22 using a Pearson's chi-squared test.
23
24
25
26
27

28 29 **Results**

30
31
32 Of the 59 FUSE-certified physicians in Japan, 56 surgeons and 1 anesthesiologist
33
34
35 completed the questionnaire (response rate 96.6%), as shown in Table 2. Almost half of
36
37
38 the participants were general surgeons (n=28, 49.1%), followed by gynecologists (n=17,
39
40
41 29.8%). Twenty-four (45.3%) participants had obtained FUSE certification within the
42
43
44 past 1–3 years, and 18 (31.6%) had obtained certification more than 3 years ago. Most
45
46
47 participants completed the FUSE examination owing to their interest in energy devices
48
49
50 (n=49, 86%) or to understand the proper use of energy devices (n=43, 75.4%).
51
52
53

54
55 However, there were no significant differences across item responses among surgical
56
57 specialties.
58
59
60
61
62
63
64
65

1
2
3 Surgical techniques using energy devices (Table 3)
4
5

6 Most participants (n=52, 91.3%) applied knowledge acquired from the FUSE program
7
8 in clinical practice. Similarly, most participants acknowledged that they changed the
9
10 way they used monopolar electrosurgery devices (n=50, 87.8%) and reported
11
12 improvements in surgical techniques (n=47, 82.5%). In contrast, a positive change in
13
14 perception was acknowledged by only approximately 50% of participants using
15
16 ultrasonic activating devices (USADs) or vessel sealing systems (VSSs). The majority
17
18 of participants reported a need for more detailed explanations within the FUSE content
19
20 related to USAD as well as further explanations for VSS, specific energy devices, and
21
22 advanced features of electrosurgical units (e.g., soft coag mode).
23
24
25
26
27
28
29
30
31
32

33
34
35 Changes in behavior and safety awareness (Table 4)
36
37

38 Almost all respondents (98.3%) reported an increase in surgical safety awareness, and
39
40 35 participants (61.5%) attempted to promote the safe use of energy devices at their
41
42 institutions. For 46 (80.7%) participants, methods of teaching colleagues about energy
43
44 devices changed. Based on the 34 descriptive answers offered by those who completed
45
46 the survey, half of the respondents felt that changes occurred primarily when they were
47
48 teaching surgical trainees about the fundamental principles and appropriate use of
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

1
2
3 Communications with surgeons and OR nurses (Table 5)
4
5

6 In terms of dispersive electrodes, while 38.6% of the participants had interactive
7
8 communication with surgeons or surgical trainees, participants had more opportunities
9
10 to communicate with OR nurses (49.2%). Overall, more than 70% of respondents had
11
12 increased communication with surgeons or nurses about the importance of cleaning
13
14 burnt materials (e.g., eschar) from the active electrode. The frequency of
15
16 communication with other surgeons/trainees and OR nurses about a topic was similar
17
18 for “electrosurgery setting” (61.4% and 59.6%, respectively) and “placement of the
19
20 handpiece (active electrode) when not in use” (43.9% and 45.6%, respectively).
21
22
23
24
25
26
27
28
29
30

31 Educational activities about energy devices (Table 6)
32
33

34 Fifty-six participants (98.2%) reported the need for systematic education in surgical
35
36 energy, with participants targeting fellows (94.7% of participants specified that fellows
37
38 should participate in further education), residents (75.4%), and attending surgeons
39
40 (63.2%) as recipients of this training. Thirty-one participants (54.4%) had some
41
42 experience teaching about energy devices to colleagues and OR staff, including didactic
43
44 lectures or workshops. Of the descriptive responses offered by 26 participants, 12
45
46 (46.2%) felt that senior surgeons’ lack of interest in the FUSE content created a barrier
47
48 to teaching activities.
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

1
2
3
4
5
6 **Discussion**
7

8
9 This study aimed to explore the impact of the FUSE program on surgeons' behavior and
10 safety awareness regarding the use of surgical energy devices. Therefore, the current
11 study survey responses suggested that participants perceived their behavior and
12 awareness regarding safe use of energy devices to be improved after FUSE certification,
13 regardless of surgical specialty. Most participants reported that post-certification, their
14 promotion of safe use of energy devices to OR personnel increased and that their
15 teaching approaches changed. Moreover, FUSE-certified surgeons have acted at various
16 levels (institutional, regional, and national) to disseminate knowledge about the safe use
17 of energy devices. This is the first study to explore the effect of FUSE certification on
18 surgeons' behavioral changes and safety awareness in practice using Kirkpatrick's
19 model, which is a widely used model to evaluate the results of educational curriculum
20 [10].
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46

47 There is a variety of evidence about the effectiveness of the FUSE program in
48 fulfilling knowledge gaps about the safe use of energy devices [7,8,11]. Previous studies
49 have shown that the knowledge and confidence levels of surgical trainees improved
50 significantly after educational intervention based on FUSE; this knowledge and
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

1
2
3 confidence were retained after three months and after one year [7,8]. In other studies,
4
5
6 most trainees reported satisfaction with the program content and potential contributions
7
8
9 to patient safety, and that they would recommend the FUSE program to colleagues [11].

10
11
12 Although previous studies have reported the effectiveness of the FUSE program, the
13
14
15 degree of application and changes in individual clinical practice due to the FUSE
16
17
18 certification are unexplored. Therefore, this study aimed to bridge this gap by exploring
19
20
21 the individual changes in clinical practice for surgical safety after obtaining the FUSE
22
23
24 program certification.
25
26

27
28 FUSE-certified surgeons in this study consistently reported improvement in their
29
30
31 monopolar electrosurgery surgical techniques; some felt the need for more detailed
32
33
34 content regarding USADs. USAD content accounts for only approximately 6% of the
35
36
37 FUSE program, whereas monopolar electrosurgery content accounts for approximately
38
39
40 50%. While the FUSE program focuses on the fundamentals of the safe use of energy
41
42
43 devices, content regarding cavitation, drilling, and appropriate range of grasping the
44
45
46 tissue and its effect of thermal spread, which can potentially cause injury, are not
47
48
49 currently explained in detail. Since USADs are widely and more frequently used
50
51
52 devices in laparoscopic surgery, this information should be explained further in the
53
54
55 FUSE program.
56
57
58
59
60
61
62
63
64
65

1
2
3 The majority of FUSE-certified surgeons reported increased awareness of surgical
4
5
6 safety and more frequent communication with colleagues and OR nurses about
7
8
9 electrosurgery-related topics. These findings of our study may indicate surgeons'
10
11
12 improved safety behavior and awareness while using surgical energy devices in practice
13
14
15 after obtaining the FUSE certification. Accordingly, FUSE-certified surgeons could
16
17
18 increasingly contribute to enhancing the safety of patients who require surgical
19
20
21 treatment. However, the frequency of conversation among surgeons around dispersive
22
23
24 electrodes barely changed. This result may be because the majority of surgeons are not
25
26
27 likely to place a dispersive electrode by themselves. Nonetheless, appropriate placement
28
29
30 of the dispersive electrode should be taught to surgeons. While most respondents
31
32
33 reported experience, or intentions of, conducting educational activities, intra-operative
34
35
36 teaching activities of energy-device-related topics must be structured and optimized.
37
38
39
40

41 Importantly, almost half of the study participants felt that the lower interest of senior
42
43
44 colleagues in the FUSE content was a barrier to conducting teaching activities. The
45
46
47 majority of respondents also felt that both attending surgeons and surgical trainees
48
49
50 should receive training in FUSE. Attending surgeons must also learn the safe use of
51
52
53 energy devices, as previous studies have shown that surgeons have knowledge gaps in
54
55
56 the safe and effective use of energy devices, regardless of experience[3,4]. Therefore,
57
58
59
60
61
62
63
64
65

1
2
3 buy-in and support from senior surgeons regarding the FUSE program is crucial for
4
5
6 further dissemination of educational activities that promote a safety culture around
7
8
9 surgical energy. Multidisciplinary approaches involving anesthesiologists, OR nurses,
10
11
12 and clinical engineers are likely to play a significant role in improving the safe use of
13
14
15 energy devices.
16

17
18
19 A strength of this study is its excellent response rate, which yields a more accurate
20
21
22 interpretation of the results. However, the data should be interpreted with caution given
23
24
25 the potential of bias. This study only collected views of FUSE certified personnel, who
26
27
28 might be strongly motivated and interested in the FUSE certification. This study has
29
30
31 other limitations as well. First, although differences between surgical specialties might
32
33
34 have affected results, the differences were not adequately considered for interpretation.
35
36
37 Surgeons prefer to use a variety of energy devices, preferences that would change for
38
39
40 each specialty. However, as this study focused on more general topics of energy, tool
41
42
43 preference by specialty would not be a significant factor. Second, surgeons' training,
44
45
46 and clinical and teaching experiences vary; therefore, the impact of their experiences on
47
48
49 their responses must be accounted for when interpreting the results. Third, the current
50
51
52 study results may reflect a response bias because only self-reported data were collected
53
54
55 without any pre-tests before obtaining FUSE certification. Fourth, the generalizability
56
57
58
59
60
61
62
63
64
65

1
2
3 of this study may be limited, as only FUSE-certified surgeons in Japan were included.
4
5

6 Moreover, inferential statistics using pre- and post-FUSE certification tests would be
7
8 required to achieve more reliable results, and further survey studies are required with
9
10 international FUSE-certified surgeons. Fifth, the institutional impact of certified
11
12 surgeons was not investigated. Although certified surgeons reported that they changed
13
14 their practice, actual improvements in behavior and awareness regarding surgical energy
15
16 in the OR remain unclear. It also remains unclear if perceived changes occurred in other
17
18 areas. Finally, this was not a comparative study between the group of FUSE-certified
19
20 surgeons and the control group. FUSE is an educational program contributing to
21
22 improving OR safety. The rate of electrosurgery related adverse events needs to be
23
24 collected to demonstrate the definitive effectiveness of the educational program.
25
26 Although a comparative study is vital to present the definitive effectiveness of FUSE
27
28 certification, collecting the comparative data would be challenging, due to the immense
29
30 effort required and lack of feasibility.
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46

47 FUSE-certified surgeons reported behavioral changes and increased awareness of
48
49 the safety of applying energy devices in their practice. They were more open to
50
51 conversation and teaching about the fundamentals of energy devices with and to other
52
53
54
55
56
57 OR personnel. Study findings suggest that FUSE certification has positive effects on the
58
59
60
61
62
63
64
65

1
2
3 safe use of energy devices in the OR. Based on these findings that FUSE certification
4
5
6 could achieve behavioral change and improved consciousness to use energy devices
7
8
9 safely and appropriately, our goal is to disseminate the FUSE program or its concept
10
11
12
13 among all surgeons to promote safe surgery.
14
15
16
17
18

19 **Acknowledgements**

20
21
22 The authors thank all FUSE-certified personnel in Japan and, especially, the participants
23
24
25 in this study. This study would not have been possible without the generosity of all
26
27
28 participants.
29
30
31
32
33
34

35 **Disclosures**

36
37
38 **Conflict of Interest:** Dr. Yusuke Watanabe received honoraria from Medtronic, Johnson
39
40
41 & Johnson, Olympus, ConMed, and AMCO outside the submitted study. Dr. Akihiro
42
43
44 Kondo, Dr. Yuichi Nishihara, Ms. Elif Bilgic, and Ms. Miho Sato have no conflicts of
45
46
47 interest or financial ties to disclose.
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

1
2
3 **References**
4
5

- 6
7 1. Aigner N, Fialka C, Fritz A, Wruhs O, Zöch G (1997) Complications in the use of
8
9 diathermy. *Burns* 23(3):256-264. DOI: [10.1016/s0305-4179\(96\)00113-1](https://doi.org/10.1016/s0305-4179(96)00113-1).
11
12
13 2. Nduka CC, Super PA, Monson JR, Darzi AW (1994) Cause and prevention of
14
15 electrosurgical injuries in laparoscopy. *J Am Coll Surg* 179(2):161-170.
16
17
18
19 3. Feldman LS, Fuchshuber P, Jones DB, Mischna J, Schwaitzberg SD, FUSE (2012)
20
21 Surgeons don't know what they don't know about the safe use of energy in surgery.
22
23
24
25
26
27 *Surg Endosc* 26(10):2735-2739. DOI: [10.1007/s00464-012-2263-y](https://doi.org/10.1007/s00464-012-2263-y).
28
29 4. Watanabe Y, Kurashima Y, Madani A, Feldman LS, Ishida M, Oshita A, Naitoh T,
30
31 Noma K, Yasumasa K, Nagata H, Nakamura F, Ono K, Suzuki Y, Matsushashi N,
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000
1. Aigner N, Fialka C, Fritz A, Wruhs O, Zöch G (1997) Complications in the use of diathermy. *Burns* 23(3):256-264. DOI: [10.1016/s0305-4179\(96\)00113-1](https://doi.org/10.1016/s0305-4179(96)00113-1).
 2. Nduka CC, Super PA, Monson JR, Darzi AW (1994) Cause and prevention of electrosurgical injuries in laparoscopy. *J Am Coll Surg* 179(2):161-170.
 3. Feldman LS, Fuchshuber P, Jones DB, Mischna J, Schwaitzberg SD, FUSE (2012) Surgeons don't know what they don't know about the safe use of energy in surgery. *Surg Endosc* 26(10):2735-2739. DOI: [10.1007/s00464-012-2263-y](https://doi.org/10.1007/s00464-012-2263-y).
 4. Watanabe Y, Kurashima Y, Madani A, Feldman LS, Ishida M, Oshita A, Naitoh T, Noma K, Yasumasa K, Nagata H, Nakamura F, Ono K, Suzuki Y, Matsushashi N, Shichinohe T, Hirano S (2016) Surgeons have knowledge gaps in the safe use of energy devices: a multicenter cross-sectional study. *Surg Endosc* 30(2):588-592. DOI: [10.1007/s00464-015-4243-5](https://doi.org/10.1007/s00464-015-4243-5).
 5. Madani A, Jones DB, Fuchshuber P, Robinson TN, Feldman LS (2014) Fundamental Use of Surgical Energy™ (FUSE): a curriculum on surgical energy-based devices. *Surg Endosc* 28(9):2509-2512. DOI: [10.1007/s00464-014-3623-6](https://doi.org/10.1007/s00464-014-3623-6).
 6. Fuchshuber P, Schwaitzberg S, Jones D, Jones SB, Feldman L, Munro M, Robinson T, Purcell-Jackson G, Mikami D, Madani A, Brunt M, Dunkin B, Gugliemi C,

1
2
3 Groah L, Lim R, Mischna J, Voyles CR (2018) The SAGES Fundamental Use of
4
5
6 Surgical Energy program (FUSE): history, development, and purpose. Surg Endosc
7
8
9 32(6):2583-2602. DOI: [10.1007/s00464-017-5933-y](https://doi.org/10.1007/s00464-017-5933-y).

10
11
12 7. Madani A, Watanabe Y, Vassiliou MC, Fuchshuber P, Jones DB, Schwaitzberg SD,
13
14
15 Fried GM, Feldman LC (2014) Impact of a hands-on component on learning in the
16
17
18 Fundamental Use of Surgical Energy™ (FUSE) curriculum: a randomized-
19
20
21 controlled trial in surgical trainees. Surg Endosc 28(10):2772-2782. DOI:
22
23
24
25 [10.1007/s00464-014-3544-4](https://doi.org/10.1007/s00464-014-3544-4).

26
27
28 8. Madani A, Watanabe Y, Vassiliou MC, Fuchshuber P, Jones DB, Schwaitzberg SD,
29
30
31 Fried GM, Feldman LS (2016) Long-term knowledge retention following
32
33
34 simulation-based training for electrosurgical safety: 1-year follow-up of a
35
36
37 randomized controlled trial. Surg Endosc 30(3):1156-1163. DOI: [10.1007/s00464-](https://doi.org/10.1007/s00464-015-4320-9)
38
39
40
41 [015-4320-9](https://doi.org/10.1007/s00464-015-4320-9).

42
43
44 9. Ministry of Health, Labour and Welfare. Ethical guidelines for medical and Health
45
46
47 Research involving human subjects. Available at: [https://www.mhlw.go.jp/file/06-](https://www.mhlw.go.jp/file/06-Seisakujouhou-10600000-Daijinkanboukouseikagakuka/0000080278.pdf)
48
49
50
51 [Seisakujouhou-10600000-Daijinkanboukouseikagakuka/0000080278.pdf](https://www.mhlw.go.jp/file/06-Seisakujouhou-10600000-Daijinkanboukouseikagakuka/0000080278.pdf). Accessed
52
53
54 29 January 2021.
55
56
57
58
59
60
61
62
63
64
65

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

10. Kirkpatrick DL, Kirkpatrick JD (2006) Evaluating Training Program. The Four Levels. 3rd ed. Berrett-Koehler Publishers, San Francisco.

11. Gugenheim J, Debs T, Gravié JF, Deleuze A, Millat B, Borie F, Mathonnet M (2020) Results of the FUSE evaluation project in France. Surg Endosc 34(4):1819-1822.
DOI: [10.1007/s00464-019-06938-0](https://doi.org/10.1007/s00464-019-06938-0).

Table 1. Questionnaire content

Section	No. of items	Type of questions and scales
1. Participant demographics	4	-
2. Surgical techniques using various energy devices	4	Likert-scale: (1) Strongly disagree - (5) Strongly agree (1) Definitely not changed/improved - (5) Definitely changed/improved Free description
3. Changes in behavior and safety awareness	4	Likert-scale: (1) Definitely not changed - (5) Definitely changed Free description
4. Frequency of communications with colleagues about electrosurgery-related topics	4	Likert-scale: (1) Definitely not changed - (5) Every case
5. Educational activities on energy devices	6	Single-choice, Multiple-choice Likert-scale: (1) Strongly disagree - (5) Strongly agree Free description

Table 2. Participant demographics (n = 57)

	n (%)
Specialties	
General surgery	28 (49)
Gynecology	17 (29.8)
Urology	4 (7)
Pediatric surgery	4 (7)
Thoracic surgery	1 (1.8)
Endocrine surgery	1 (1.8)
Otolaryngology	1 (1.8)
Anesthesiology	1 (1.8)
Reasons for learning about energy devices via the FUSE program ^a	
Professional curiosity about energy devices	49 (86)
Learning the proper use of energy devices	43 (75.4)
Teaching surgical trainees	19 (33.3)
Years since date of FUSE certification	
< 0.5 year	8 (14)
0.5–1 year	7 (12.2)
1–3 years	24 (42.1)
> 3 years	18 (31.6)

Table 3. Self-reported changes in surgical technique using each energy device (n = 57)

	Strongly disagree				Strongly agree
	1	2	3	4	5
	n (%)				
Changes in the use of energy devices in practice	0 (0)	1 (1.8)	4 (7)	25 (43.9)	27 (47.4)
	Definitely not changed				Definitely changed
	1	2	3	4	5
	n (%)				
Changes in surgical technique:					
Monopolar electrosurgery	0 (0)	1 (1.8)	6 (10.5)	12 (21.1)	38 (66.7)
USAD	3 (5.3)	4 (7)	19 (33.3)	25 (43.9)	6 (10.5)
VSS	2 (3.5)	4 (7)	21 (36.8)	23 (40.4)	7 (12.3)
	Definitely not improved				Definitely improved
	1	2	3	4	5
	n (%)				
Improvements in surgical technique:					
Monopolar electrosurgery	0 (0)	0 (0)	10 (17.5)	23 (40.4)	24 (42.1)
USAD	2 (3.5)	5 (8.8)	20 (35.1)	28 (49.1)	2 (3.5)
VSS	2 (3.5)	4 (7)	20 (35.1)	28 (49.1)	3 (5.3)

USAD = ultrasonic activating device; *VSS* = vessel sealing system

Table 4. Self-reported changes in behavior and safety awareness (n = 57)

	Definitely not changed				Definitely changed
	1	2	3	4	5
	n (%)				
Awareness of surgical safety	0 (0)	0 (0)	1 (1.8)	25 (43.9)	31 (54.4)
Content of the teaching	0 (0)	0 (0)	11 (19.3)	26 (45.6)	20 (35.1)
	Definitely not approached				Definitely approached
	1	2	3	4	5
	n (%)				
Approaches to promote the safe use of energy devices in each institution	1 (1.8)	4 (7)	17 (29.8)	23 (40.4)	12 (21.1)

Table 5. Frequency of communication with surgeons and operating room nurses about the following topics (n=57)

	With surgeons / ORNs	Definitely not changed				Every case
		1	2	3	4	
		n (%)				
Electrosurgery setting	Surgeons	4 (7)	6 (10.5)	12 (21.1)	26 (45.6)	9 (15.8)
	ORNs	4 (7)	7 (12.3)	12 (21.1)	28 (49.1)	6 (10.5)
Dispersive electrode	Surgeons	6 (10.5)	9 (15.8)	20 (35.1)	17 (29.8)	5 (8.8)
	ORNs	7 (12.3)	6 (10.5)	16 (28.1)	23 (40.4)	5 (8.8)
Placement of the handpiece (active electrode) when not in use	Surgeons	5 (8.8)	12 (21.1)	15 (26.3)	20 (35.1)	5 (8.8)
	ORNs	8 (14)	7 (12.3)	16 (28.1)	24 (42.1)	2 (3.5)
Cleaning burnt materials (e.g., eschar) from active electrode	Surgeons	4 (7)	5 (8.8)	8 (14)	25 (43.9)	15 (26.3)
	ORNs	3 (5.3)	6 (10.5)	7 (12.3)	27 (47.4)	14 (24.6)

ORN = operating room nurse

Surgeons include senior or junior surgeons and surgical trainees

Table 6. Energy device educational activities (n=57)

	n (%)
Participated in FUSE workshop	
Yes	45 (78.9)
No	12 (21.1)
Need for systematic education in surgical energy	
5 strongly agree	46 (80.7)
4	10 (17.5)
3	1 (1.8)
2	0 (0)
1 strongly disagree	0 (0)
Preferred targets for education ^a	
Medical students	21 (35.8)
Residents	43 (75.4)
Fellows	54 (94.7)
Attending surgeons	40 (70.2)
Attending surgeons with teaching responsibilities	36 (63.2)
Experience teaching surgical energy (e.g., didactic lecture or workshop)	
Yes	31 (54.4)
No	26 (45.6)
If “No,” intention of conducting teaching activities	
Yes	21 (80.7)
No intention	1 (3.9)
Unknown	4 (15.4)

FUSE = Fundamental Use of Surgical Energy

^aRespondents could choose more than one response

Supplementary Material

Supplemental Text 1. Self-reported content changes teaching about surgical-energy devices (34 descriptive responses summarized)

- Logical explanations based on principles
- Teaching with hands-on demonstrations
- Explanations of practical use focusing on tissue effect, activation time
- Importance of lower voltage output
- Use low voltage continuous outputs (“cut mode output”) to seal vessels
- Applications and practical use of the cut mode output
- Differences in output modes (eg, cut mode vs. coag mode)/power and practical applications of each mode
- Lateral thermal spread among output modes
- Positions of dispersive electrodes
- Potential adverse effect of electrosurgery (eg, residual heat injury, capacitive coupling, operating room fire) and how to avoid it
- Avoid open activation (not activating the electrode before it becomes in contact with the targeted tissue)
- Controlling current density by changing the contact area of active electrode