Use of Computer-Assisted Instrument Guidance Technology by Student Registered Nurse Anesthetists for Simulated Invasive Procedures

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This study was conducted to determine if computer-assisted instrument guidance (CAIG, Clear Guide Medical), with an optical tracking mechanism, enhances simulated transversus abdominis plane (TAP) block performance in a porcine model by novice student registered nurse anesthetists (SRNAs) compared with standalone ultrasonography (US). In a crossover design, 26 students were randomly assigned into 2 groups: US only and CAIG. Performance was assessed using a task-specific checklist survey tool and a global rating scale to assess performance. Time to hydrodissection and number of insertion attempts were recorded. A pre-procedure and postprocedure survey obtained participants' demographics and measured overall experience. Results revealed higher mean scores for all items in the global rating scale and overall performance (P = .010). The checklist survey results indicated no significant between-group differences. The CAIG group was observed to have significantly lower simulated block performance times (P = .037) and number of attempts (P = .002). The postprocedure survey results showed most participants (88%) reported an enhanced experience using the CAIG. Use of the CAIG showed favorable results in novice SRNAs performing the simulated block. Procedure performance, number of attempts, and time to complete were significantly lower, with a strong preference for the CAIG system.

Keywords: Education, computer-assisted instrument guidance, transversus abdominis plane block, ultrasound.

Unabated postprocedure pain is associated with increased length of hospital stay, increased risk of chronic pain, elevated hospital costs, and lower patient satisfaction scores in more than 75% of patients.[1-3] Traditionally, treatment of postoperative pain entailed solely the use of varying doses and types of opioids. However, with the opioid epidemic now a public health crisis, anesthesia providers are increasingly using regional anesthesia techniques as an alternative to opioids. Both the American Society of Regional Anesthesia and Pain Medicine (ASRA) and the European Society of Regional Anesthesia and Pain Therapy (ESRA) offer guidelines for ultrasound-guided regional anesthesia training, which include recommendations for simulation-specific training.[4] The simulation setting is also described as the optimal environment for trialing new technology and comparing novel techniques to current modalities before utilization in clinical practice.[4]

The transversus abdominis plane (TAP) block, first described in 2001, is an anatomical landmark–based peripheral nerve block technique involving needle insertion at the triangle of Petit (lumbar triangle).[5] The procedure results in blockade of the afferent nerves supplying the anterior abdominal wall (T7-L1).[5] This block has been used as an effective component of multimodal postoperative analgesia for a wide variety of abdominal procedures, including bowel resection, renal transplant surgery, cesarean delivery, appendectomy, total abdominal hysterectomy, and cholecystectomy.[6] Since the conception of TAP blocks, techniques have evolved and may be performed "blind," laparoscopically, or in an ultrasound-guided manner. A number of studies and systematic reviews have been published whose results confirm the validity of TAP blocks as a component of multimodal analgesia and show effectiveness of the block in decreasing postoperative opioid consumption.[6-10]

• ***Benefits of Ultrasound Guidance.*** When performing TAP blocks, the provider may find it technically difficult to palpate the triangle of Petit using a traditional landmark technique. Ultrasound guidance allows the ability for provider identification of specific anatomical structures beneath the skin, real-time needle tip visualization, and observation of the spread of local anesthetic. Since publication of a case study involving a blind TAP block that resulted in an unintentional liver puncture,[11] experts have y advocated for the use of ultrasound guidance in all future TAP blocks.[12,13]

In a blinded prospective study, 36 patients received a TAP block via the landmark technique. Confirmation of final needle tip position and local anesthetic spread was

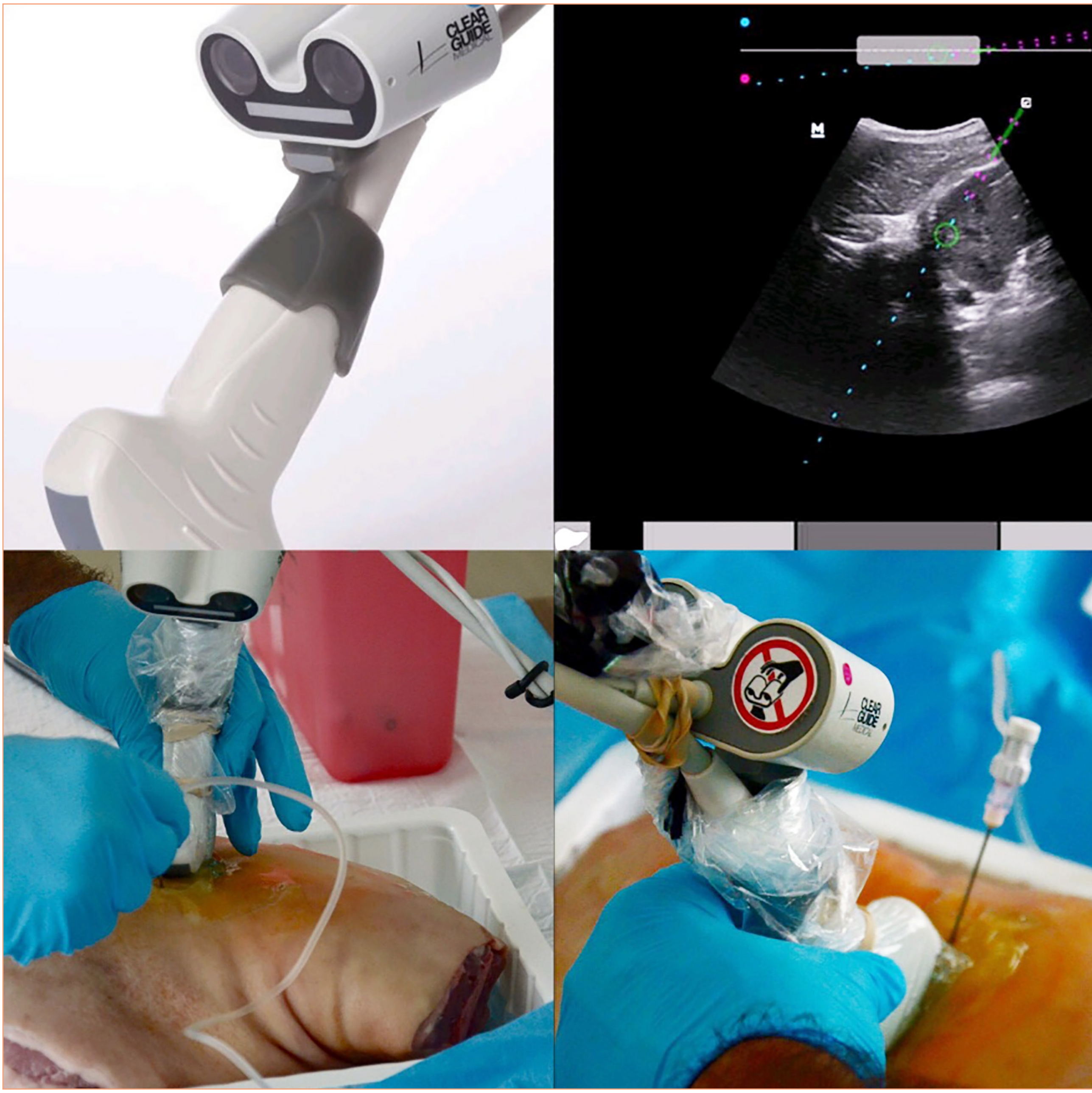

Figure. Components of Computer-Assisted Instrument Guidance (CAIG) System and Porcine Model.
Top left, Optical tracking navigation accessory (Clear Guide Medical). Top right, CAIG system with orientation guidance in use. Bottom left, Porcine shoulder model. Bottom right, In-plane technique on porcine model.

performed using ultrasound guidance. Only 23.6% of the injections were in the correct plane, resulting in early termination of the study and arguing against any blind approach.[14] Growing evidence of the benefits of ultrasonography (US) technology in peripheral nerve blocks concludes that ultrasound guidance shortens performance time,[15,16] reduces the number of needle passes,[15,17,18] results in fewer vascular punctures,[16-18] shortens the block onset time,[15-17,19] reduces the dose of the local anesthetic,[20-22] and leads to longer nerve block duration.[16]

• ***Clear Guide One Orientation Technology.*** In an effort to further enhance the performance of ultrasound-guided procedures, Clear Guide Medical has developed a Food and Drug Administration–approved computer-assisted instrument guidance (CAIG) device (Figure top left and right), which provides optical tracking through the addition of a navigation accessory. This produces real-time virtual instrument guidance by overlaying the projected needle pathway onto a live ultrasound image. Ultimately, the CAIG allows needle path visualization of the ultrasound imaging plane and angle of entry before skin penetration. This technique improves accuracy by decreasing the need for needle redirections.

A randomized controlled trial using the CAIG system to determine its efficacy in midcatheter procedures has shown favorable results in decreasing the number of attempts, first-attempt success rate, and median time for vascular access.[23] Overall, the data suggested that the CAIG technology greatly diminished time and improved likelihood of quick catheterizations compared with traditional US technology.[23] Novice residents were observed performing ultrasound-guided needle placement with and without the CAIG technology. Results reported that 50% of residents preferred the CAIG technology; 67% had an increased confidence level with the device; and 95% perceived improvement in speed, accuracy, or both.[24]

Novice learners develop mastery of ultrasound guidance for performing invasive procedures through hands-on training with the guidance of faculty in both the simulated environment and clinical settings. However, for inexperienced users, US-guided imaging technology itself poses a challenge. Studies show that simulation sessions can help to improve a novice operator's speed, accuracy, and overall success rate in performing ultrasound-guided regional procedures after approximately 6 task repetitions.[25,26] The CAIG accessory device seeks to further aid in the proficiency of US use.

The aim of this study was to determine if the computer-assisted technology improved performance of novice student registered nurse anesthetists (SRNAs) in a simulated invasive TAP block procedure compared with the US-alone technique. The objectives were to gather evidence with respect to performance, time to perform, and number of attempts to perform the simulated procedure.

Materials and Methods

Our university institutional review board committee approved the study and waived the requirement for consent of participants. A convenience sample of 26 SRNAs from a private university was enrolled in the study during the second-year fall semester of their educational program. An a priori sample size for *t* tests was calculated using an anticipated effect size of 0.8 with a desired statistical power level of 0.8 and probability level of .05. The minimal sample size per group was calculated to be 21 for a 1-tailed hypothesis and 26 per group for a 2-tailed hypothesis.

The fall semester timeframe was chosen because it coincided with the instructional content provided through the program's curriculum. The semester consisted of a 14-week-long immersive experience in regional anesthesia. The didactic and simulation-based curriculum was based on a training protocol starting with ultrasound imaging, functional anatomy, and pharmacology, then progressing to modules focused on upper extremities, lower extremities, neuraxial, central/truncal blocks, advanced airway, and continuous blocks. Didactic content preceded the simulation component of the curriculum. Each week students were guided through the simulated experiences developing basic skills, such as hand-eye coordination and manipulating 3-dimensional space using a 2-dimensional US display. Learning objectives and metrics were provided for each weekly module.

All participants were notified in advance through the distribution of a letter of introduction before the scheduled simulation workshop to ensure students understood what participation involved. The experiment was conducted in 2 parts during 8 regularly scheduled simulation-based workshops occurring from September 2017 to November 2017. Students were informed that participation was voluntary, and they would not be penalized for declining to participate.

This quasi-experimental descriptive study used a randomized crossover method, with each cohort of SRNAs randomly allocated into 1 of 2 groups based on prior-determined simulation class groups, which were randomized via a learning management system (Blackboard). Group 1 performed the simulated invasive procedure using the US-alone technique followed by placement of the block using the CAIG US system. The second group performed the simulated invasive procedure with the CAIG US system followed by using the US-alone technique. This resulted in each subject performing the invasive procedure twice using each technique and ultimately serving as his or her own control.

• ***Measures.*** The researchers developed a pre-procedural baseline data survey to capture demographic data about gender, age, years of nursing experience, and experience with TAP blocks to determine if differences were appreciated among these descriptive variables with TAP block performance. To investigate and compare the students' performances with each technique, we used a task-specific checklist survey tool (TSCST) and the generic technical skills global rating scale (GRS) developed by Sultan et al[27]; these tools addressed the stepwise approach of novices in performing technical skills. Construct validity was established by Sultan et al for the TSCST and GRS using interclass correlations between assessors and were calculated as 0.842 and 0.795, respectively.

We modified the TSCST to reflect the steps necessary to perform the simulated TAP block procedure, instead of an ultrasound-guided axillary brachial plexus block. The GRS was unchanged, provided an overall assessment of the student's performance, and consisted of a 5-point Likert scale ranging from very poor (1) to clearly superior (5). Additionally, the number of attempts and total time to perform a successful simulated TAP block were measured. Following performance of the procedure, the SRNAs completed an anonymous survey that assessed their impression of the CAIG system and their overall experience with both techniques.

• ***Procedure.*** A pre-procedure survey ascertained demographic information, prior experience with TAP blocks,

Characteristic	Median (IQR)	Number (%)
Gender	—	
Male		9 (34.6)
Female		17 (65.4)
Years of nursing experience	3 (3.0-4.0)	
1-2		2 (7.7)
3-5		14 (53.8)
6-8		6 (23.1)
9-10		2 (7.7)
> 10		2 (7.7)
Prior experience with ultrasound-guided regional block procedures		
No		9 (34.6)
Yes		17 (65.4)
Number of ultrasound-guided regional block procedures	2 (1.0-2.0)	
None		8 (30.8)
1-4		14 (53.8)
5-9		3 (11.5)
10-14		1 (3.9)
Level of confidence with ultrasound-guided regional block procedures	2 (1.0-2.0)	
No confidence		9 (34.6)
Little confidence		16 (61.5)
Very confident		1 (3.9)

Table 1. Participant Characteristics (N = 26)
Abbreviation: IQR, interquartile range.

and perceived confidence level. In a randomized order, participants performed a simulated TAP block using the US-alone technique or the CAIG US system in a porcine shoulder model (Figure bottom left and right). The SRNAs were observed and evaluated using the GRS and the modified TSCST. All participants were supervised by an expert in regional anesthesia. To further ensure treatment fidelity, we standardized training for all supervising faculty assisting with this study. Methods included educational sessions regarding use of the CAIG and the TSCST and GRS instruments, as well as modeling of the TAP block with and without CAIG until understanding was demonstrated. The supervising clinician was allowed to intervene to provide necessary training guidance as part of the curriculum's learning objectives. The number of attempts to perform and time until success were measured. Two weeks later, the participants then performed the simulated invasive procedure with the alternate technique and were evaluated using the same GRS and TSCST. Following both performances, participants were asked to evaluate and compare their experiences using the CAIG system.

• ***Porcine Model.*** The use of organic phantom models, such as meat, is noted to produce the most realistic sonographic anatomy and tactile perception while permitting injection and catheter insertion during training sessions.[4] Thus, we elected to use a porcine model with a store-bought pork shoulder, which was used to perform a simulated TAP block (Figure bottom left and right). The porcine model provided ideal sonographic imaging with similar identifiable fascial planes and a realistic feel for tissue.[28] The similar identifiable fascial plane was an important determinate because targeted nerves for the TAP block lie in the fascial plane between the internal oblique and transversus abdominis muscles. The porcine model was placed in a skin-up position. The pork shoulder was deodorized by soaking it in 70% alcohol before use. Ultrasound imaging was conducted using the Mindray TE7 US machine (Mindray North America) with a curved array transducer probe. Needling was performed with an in-plane technique. Once the needle tip was confirmed in the fascial plane, hydrodissection employing an anesthetic solution was injected to separate the nerve from the surrounding tissue.

• ***Computer-Assisted Instrument Guidance Device.*** The CAIG device was leased to the anesthesia program primarily for training purposes with the secondary goal of studying its use in the novice learner. At no time was the company involved in the design and implementation of the study; nor did it influence the results obtained.

Results

A total of 26 SRNAs, ranging from 25 to 45 years of age, participated in this study. Baseline demographic characteristics for the groups of volunteers are summarized in Table 1. A total of 17 (65.4%) of the participants stated having previously performed a minimum of 1 regional block procedure with the aid of ultrasound guidance. When reporting the estimated total number of prior ultrasound-guided regional blocks performed, responses were greatest in the group of 1 to 4 insertions (53.8%). Although more than half of the participants responded to having prior experience with this technique, respondents

Survey item	CAIG (N= 24), No. (%) of yes responses	Ultrasound guidance alone (N = 24) No. (%) of yes responses	*P* value
Positioning			
Exposure of the anatomical site	24 (100)	24 (100)	> 0.99
Ultrasound screen	24 (100)	24 (100)	> 0.99
Sterile setup	24 (100)	24 (100)	> 0.99
Preparation			
Open kit and inspect contents	24 (100)	24 (100)	> 0.99
Draw up local anesthetic	24 (100)	24 (100)	> 0.99
Needle preparation	24 (100)	24 (100)	> 0.99
Application of gel	24 (100)	23 (95.8)	> 0.99
Performing			
Application of antiseptic to site	24 (100)	24 (100)	> 0.99
Short axis orientation of probe	24 (100)	24 (100)	> 0.99
Identification of anatomy	24 (100)	24 (100)	> 0.99
In-plane with needle in view	24 (100)	23 (95.8)	> 0.99
Needle tip seen before injection	24 (100)	23 (95.8)	> 0.99
Aspiration before injection	24 (100)	15 (100)	0.04[a]
Test dose given; spread seen	24 (100)	24 (100)	> 0.99

Table 2. Task-Specific Ultrasound-Guided Survey Ratings
Abbreviation: CAIG, computer-assisted instrument guidance (Clear Guide Medical).
[a]Significant.

disclosed that they felt "little" (61.5%) to "no" confidence (31.6%) placing regional blocks under ultrasound guidance at the time of the baseline survey.

• ***Task-Specific Ultrasound-Guided TAP Block Survey.*** All students participated in 2 sessions performing TAP blocks. One session entailed performing the procedure under ultrasound guidance only, and the other session employed the CAIG-assisted US procedure. Of the 52 total datasets associated with the Task-Specific Ultrasound-Guided Survey (modified TSCST), it was noted that 1 participant erroneously entered performing the ultrasound-guided technique twice. It was also identified that 2 separate participants entered a code that did not match any of the codes on the other surveys. The data were cleaned to reflect the removal of these 3 student cases, resulting in 48 analyzed datasets for this survey. This adjustment resulted in 24 datasets in each of the 2 group conditions. McNemar tests were run for these 2 dependent groups composed of the same dichotomous output variables. Descriptive summaries for task-specific ratings are shown for each participant group in Table 2. Group differences were noted in the application of gel, maintaining needle view at all times, needle tip identified before injection of local anesthetic, and needle aspiration before injection. There was a significant difference (P = .04) noted in the proportion of participants who aspirated the needle before injection of local anesthetic, with the CAIG group (100%) outperforming the ultrasound-guided-only group (62.5%).

Wilcoxon signed rank tests were conducted for the following continuous variables, which were not normally distributed: time to perform simulated TAP block, number of attempts, and distance from skin to fascial plane. A Wilcoxon signed rank test indicated that the median time for performing a successful simulated TAP block was significantly lower using the CAIG procedure than median time for the US-only technique (Z = 3.033, P = .002). Time in minutes for performing a simulated TAP block was also significantly lower using the CAIG procedure than median time for the US-only technique (Z = 2.083, P = .037). The median distance in centimeters from skin to fascial plane was not significantly deeper using the CAIG than without its use (Z = 1.115, P = .265).

• ***Generic Technical Skills Global Rating Scale.*** One participant's generic technical skills GRS result was absent from the dataset, resulting in a total of 25 surveys in this analysis. A Wilcoxon signed rank test was conducted for all ranked variables for the dependent CAIG and US-only groups (Table 3). The results showed that CAIG group scores were significantly higher for all variables than the group not using the CAIG (US alone). A Wilcoxon signed rank test indicated that the median scores for the respect for tissue and time and motion categories were significantly higher for participants using the CAIG procedure than the median scores of those using US alone, Z = 3.337, P = .001 and Z = 3.237, P = .001, respectively. Scores were also significantly higher for the CAIG group in the instrument handling (Z = 2.714, P =

Skill/rating	Without CAIG (N = 27), No. (%)	With CAIG (N = 24), No. (%)	*P* value[b]
Respect for tissue			.001
Very poor	0 (0)	0 (0)	
Below competent	0 (0)	1 (4.2)	
Competent	4 (14.8)	19 (79.2)	
Above competent	11 (40.7)	2 (8.3)	
Clearly superior	12 (44.4)	2 (8.3)	
Time and motion			.001
Very poor	0 (0)	0 (0)	
Below competent	1 (3.7)	4 (16.7)	
Competent	5 (18.5)	16 (66.7)	
Above competent	9 (33.3)	2 (8.3)	
Clearly superior	12 (44.4)	2 (8.3)	
Instrument handling			.007
Very poor	0 (0)	0 (0)	
Below competent	2 (7.4)	0 (0)	
Competent	6 (22.2)	19 (79.2)	
Above competent	7 (25.9)	2 (8.3)	
Clearly superior	12 (44.4)	3 (12.5)	
Knowledge of instrument			.002
Very poor	0 (0)	0 (0)	
Below competent	1 (3.7)	1 (4.2)	
Competent	7 (25.9)	19 (79.2)	
Above competent	8 (29.6)	0 (0)	
Clearly superior	11 (40.7)	4 (16.7)	
Flow of procedure			.011
Very poor	0 (0)	0 (0)	
Below competent	1 (3.7)	0 (0)	
Competent	8 (29.6)	18 (75)	
Above competent	6 (22.2)	3 (12.5)	
Clearly superior	12 (44.4)	3 (12.5)	
Use of assistants			.003
Very poor	0 (0)	0 (0)	
Below competent	0 (0)	3 (12.5)	
Competent	5 (18.5)	16 (66.7)	
Above competent	10 (37)	1 (4.2)	
Clearly superior	12 (44.4)	4 (16.7)	
Knowledge of procedure			.003
Very poor	0 (0)	0 (0)	
Below competent	1 (3.7)	1 (4.2)	
Competent	7 (25.9)	17 (70.8)	
Above competent	7 (25.9)	2 (8.3)	
Clearly superior	12 (44.4)	4 (16.7)	
Overall performance			.001
Very poor	0 (0)	0 (0)	
Below competent	3 (11.1)	0 (0)	
Competent	5 (18.5)	19 (79.2)	
Above competent	7 (25.9	2 (8.3)	
Clearly superior	12 (44.4)	3 (12.5)	

Table 3. Generic Technical Skills Global Ratings[a]

Abbreviation: CAIG, computer-assisted instrument guidance (Clear Guide Medical).

[a]Some percentages may not total to 100% because of rounding.

[b]All *P* values are significant.

.007) and knowledge of instrument (Z = 3.091, P = .002) categories. The flow of procedure (Z = 2.543, P = .011) and use of assistants (Z = 3.003, P = .003) also showed that the higher median scores were represented in the CAIG group. Finally, median scores for the knowledge of procedure (Z = 3.201, P = .001) and overall performance (Z = 2.584, P = .010) variables were significantly higher for participants in the CAIG group than the median scores of the ultrasound-guided-only group.

• ***Simulation Performance Survey.*** A total of 25 students completed the survey. A 1-sample t test was used for the analysis of 14 normally distributed item responses from the CAIG Simulation Performance Survey (Table 4). Not included in this part of the analysis was the comment portion of the survey where students were able to submit individual feedback at the end of the study in a free-text box. The 1-sample t test was performed to determine the 95% confidence interval (CI) for participant responses to the 14 items. Of the students, 82% somewhat agreed that the animal model provided a realistic tactile experience, and nearly half of the participants (48%) strongly agreed the model possessed a realistic echogenic appearance.

More than half of the responses indicated that students at least somewhat agreed that they felt comfortable using the CAIG system (56%, 95% CI = 6.22-8.66). Of the responses, 96% of the students cited the successful performance of the TAP block using the CAIG. Nearly half of the participants strongly agreed that using the CAIG enhanced the overall ultrasound-guided experience (48%, 95% CI = 8.21-9.63) and increased the ease of performing the TAP block (44%, 95% CI = 7.03-9.13). Additionally, approximately one-third of the participants strongly agreed that using the CAIG increased their ability to locate anatomical structures (32%, 95% CI = 6.61-8.75), enhanced their confidence in needle position (36%, 95% CI = 7.08-9.16), and helped to improve motor skills (36%, 95% CI = 7.16-9.08) while performing the regional anesthetic procedure.

Although nearly one-third of the students indicated that their first impression was that the CAIG was probably a useless tool (32%, 95% CI = 4.75-8.45), once they had used it, most of the SRNAs strongly agreed that the tool was valuable for performing regional anesthesia (56%, 95% CI = 7.65-9.47) and for teaching ultrasound-guided blocks (56%, 95% CI = 8.31-9.61). Most of the participants strongly agreed the CAIG was a user-friendly device (60%, 95% CI = 7.69- 9.75), which increased the ease of performing the simulated TAP block (68%, 95% CI = 1.48-1.88).

Discussion

In this study, the CAIG system demonstrated favorable results in observed novice SRNAs performing simulated TAP blocks in a porcine model. All generic technical skills, including instrument handling and flow of the procedure, were significantly enhanced using the CAIG system. The number of attempts taken and the time to perform the simulated TAP block were observed to be significantly lower. The overall performance was significantly enhanced with the use of the CAIG system. Surveyed SRNAs reported a positive impression and indicated a preference for the CAIG device in their overall ultrasound-guided block experience over US alone.

The reported results reflect recent work conducted by 2 separate research teams looking at the use of the CAIG system (Clear Guide Medical) for invasive procedures. In a study investigating CAIG for use by emergency medicine residents for invasive procedures, the CAIG group significantly outperformed the US-alone group in mean time to target, number of needle redirections, and procedural accuracy.[24] In this prior study, 50% of residents preferred the guidance system, with 67% reporting an increased confidence. Most (94%) reported improvements in speed, accuracy, or both. Most recently, researchers showed the use of the CAIG system significantly shortened renal access time compared with conventional US (79.4 vs 51.1 seconds; P = .009).[29] The number of needle course corrections was also found to be significantly decreased (0.48 vs 2.53; P < .001). The researchers found that novice users were significantly faster when using the CAIG system (70 seconds vs 126 seconds; $P \le .052$). When they assessed subject preference, 73% of participants preferred the CAIG system to conventional US.

Similar findings were found in this study, in which 68% of novice users reported that the use of the CAIG system increased the ease of performing the procedure over US alone. In fact, more than one-third of the novice users found that the CAIG system increased their ability to locate structures and enhanced their confidence while improving motor skills. The CAIG group also significantly outperformed the US-alone group in the number of attempts and mean time to perform the procedure.

This study was conducted on a pork shoulder to mimic the procedure of hydrodissection between fascial planes during the performance of a simulated TAP block in a porcine model. This potentially limits applicability to clinical procedural performance in a human model. Although the sample size was small, the participants were randomly assigned into groups, as a means for determining which system the SRNAs would be exposed to first. Since the study took place as part of the students' existing curriculum, tight study control was not possible. The use of a crossover design was valuable, as the students served as their own control, but it is plausible that the small sample size may have resulted in a type II error and may limit the external validity of our findings. Two results of possible biases include knowledge of procedure and aspiration before injection of local anesthetic. Both results showed significance using the CAIG system compared with US alone. Knowledge of procedure may be explained by the

Survey item/rating	Number (%)	95% CI
Clear Guide[a] is user-friendly		7.69-9.75
Strongly disagree: 1	0 (0)	
2	2 (8)	
7	1 (4)	
8	4 (16)	
9	3 (12)	
Strongly agree: 10	15 (60)	
Model provided realistic tactile experience		6.61-8.27
Strongly disagree: 1	1 (4)	
4	2 (8)	
5	1 (4)	
6	3 (12)	
7	3 (12)	
8	3 (12)	
9	12 (48)	
Strongly agree: 10	0 (0)	
Model had realistic echogenic appearance		7.42-9.30
Strongly disagree: 1	1 (4)	
4	1 (4)	
5	1 (4)	
7	3 (12)	
8	5 (20)	
9	2 (8)	
Strongly agree: 10	12 (48)	
Successful procedure performance with Clear Guide		0.96-1.12
Yes	24 (96)	
No	1 (4)	
Increased performance speed locating structures		6.61-8.75
Strongly disagree: 1	1 (4)	
2	1 (4)	
4	1 (4)	
5	2 (8)	
6	2 (8)	
7	1 (4)	
8	5 (20)	
9	4 (16)	
Strongly agree: 10	8 (32)	
Increased procedure performance ease		7.03-9.13
Strongly disagree: 1	1 (4)	
2	1 (4)	
5	2 (8)	
6	1 (4)	
7	1 (4)	
8	6 (24)	
9	2 (8)	
Strongly agree: 10	11 (44)	
Enhanced confidence in needle position		7.08-9.16
Strongly disagree: 1	2 (8)	
5	1 (4)	
6	1 (4)	
7	1 (4)	
8	6 (24)	
9	5 (20)	
Strongly agree: 10	9 (36)	
Enhanced overall ultrasound-guided experience	8.21-9.63	
Strongly disagree: 1	0 (0)	
2	1 (4)	
7	2 (8)	
8	3 (12)	
9	7 (28)	
Strongly agree: 10	12 (48)	
Comfortable using Clear Guide		6.22-8.66
Strongly disagree: 1	2 (8)	
3	1 (4)	
4	3 (12)	
6	2 (8)	
8	5 (20)	
9	3 (12)	
Strongly agree: 10	9 (36)	
Helped improve psychomotor skills		7.16-9.08
Strongly disagree: 1	1 (4)	
4	1 (4)	
5	1 (4)	
6	2 (8)	
7	3 (12)	
8	4 (16)	
9	2 (8)	
Strongly agree: 10	11 (44)	
Valuable tool for performing regional anesthesia		7.65-9.47
Strongly disagree: 1	1 (4)	
4	1 (4)	
7	3 (12)	
8	6 (24)	
Strongly agree: 10	4 (56)	
Valuable tool for teaching ultrasound		8.31-9.61
Strongly disagree: 1	0 (0)	
4	1 (4)	
6	1 (4)	
7	2 (8)	
8	3 (12)	
9	4 (16)	
Strongly agree: 10	4 (56)	
First impression of Clear Guide		4.75-8.45
Extremely useless: 1	2 (8)	
3	1 (4)	
4	1 (4)	
5		
6	5 (20)	
7	10 (40)	
9	1 (4)	
Extremely useful: 10	1 (4)	
Easier to perform regional block with		1.48-1.88
Ultrasound-guided without Clear Guide	8 (32)	
Ultrasound-guided with Clear Guide	17 (68)	

Table 4. Simulation Performance Survey Ratings (N = 25)
[a]Computer-assisted instrument guidance system (Clear Guide Medical).

pre-procedure study orientation to the CAIG system contributing to knowledge enhancement. In the proportion of participants who aspirated the needle before injection of local anesthetic, the findings may be explained by the crossover design and resulting carryover effect from non-aspiration before injection of local anesthetic on the first attempt that was corrected on the second attempt.

Despite these limitations, this study highlights important findings. The addition of the CAIG system enhances novice provider performance of invasive procedures while decreasing both the time and number of attempts needed to perform the simulated procedure. The impact of this study on clinical outcomes has yet to be determined; the findings can make only inferences about clinical outcomes because they were not the focus of this study. Despite this, we believe the procedures employed in the novice SRNAs' performance of an invasive procedure (TAP block) in a simulated environment should lead to improved competence and therefore improved clinical performance. Future studies should assess the CAIG system's use by the novice and expert provider in a variety of peripheral nerve blocks of various depths and complexity with a focus on patient outcomes, feasibility, and cost-effectiveness.

The value of US as an important clinical tool is clear, and its use in medical education has increased dramatically over the past several decades. Ultrasound-guided imaging has become a standard practice for many anesthesia providers and is now an essential skill for graduating SRNAs. The challenge is that ultrasound guidance requires the application of a number of complex procedural techniques along with image interpretation. Use of a real-time computer-assisted navigation device, such as the CAIG, can improve motor skills and lead to an increase in speed, confidence, and accuracy in performing invasive procedures. Deliberate practice using the CAIG system is a novel approach to building confidence and the necessary skills in training to improve results. The use of the CAIG system has the potential to further enhance the education of novice providers and should be considered an adjunct in both medical education and clinical practice. This system has the potential to change how clinical educators teach and perform ultrasound-guided procedures, benefiting the learner and the patient alike.

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