

Research Article

An Innovative Surgical Generator for Multiple Energy Modalities

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Abstract

Background: Electrosurgery has evolved significantly since its inception, with advancements in generator technology improving safety and efficacy. This study evaluates the performance and usability of the Dualto Energy System, a new multi-modal surgical energy platform combining core electrosurgery with enhanced monopolar, advanced bipolar, and ultrasonic capabilities. **Methods:** Benchtop testing assessed vessel sealing strength and thermal spread of Dualto compared to existing electrosurgical generators (GEN11 and MEGEN1) using various energy modalities and devices. Waveform and energy analysis was used to confirm electrical isolation of Dualto generators in expanded configuration. Preclinical studies evaluated hemostasis, thermal damage, and tissue healing in acute and chronic animal models. Surveys were conducted with surgeons, nurses, and biomedical technicians to assess usability and perceived benefits. An acquisition cost calculator was developed to estimate potential cost savings associated with Dualto implementation. **Results:** Benchtop testing demonstrated non-inferior vessel burst pressure for Dualto compared to GEN11. Thermal spread was comparable between generators, with slight increases observed in specific Dualto monopolar modes. Waveform analysis confirmed electrical isolation of Dualto generators. Dualto exhibited significantly faster frequency lock and transection speeds for ultrasonic devices. Preclinical studies demonstrated non-inferior hemostasis and thermal damage profiles for Dualto in both single and expanded configurations. Chronic preclinical studies met success criteria for hemostasis and tissue healing. HCP survey results indicated positive user perceptions regarding Dualto usability, efficiency, and potential cost savings. The cost calculator projected potential annual savings through reduced operating room time and maintenance. **Conclusion:** The Dualto Energy System demonstrates comparable or improved performance across multiple energy modalities compared to existing systems. Its modular design, combined with positive user feedback and potential cost savings, suggests that Dualto will be a useful addition to surgical energy technology in the operating room.

Keywords

Electrosurgery, Generator, Monopolar, Bipolar, Advanced Bipolar, Ultrasonic, Modular Design

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1. Introduction

While cautery has likely been in use surgically since pre-historic times, [1-3] it was not until 1926 when William T. Bovie and Harvey Cushing developed reliable generators that electrosurgery was established as an indispensable tool within the surgeon's arsenal. [4, 5] Electrosurgical generators produce electrical currents for both monopolar and bipolar devices, enabling the cutting and coagulation of tissue. These generators provide control over the power delivered, which is intended to yield effective surgical outcomes while minimizing damage to surrounding tissues. Additionally, they are designed to enhance safety by incorporating features that monitor and regulate current flow during procedures [6].

Advances in generator design over the past century have led to improvements in its safety and efficiency. For example, starting in the 1970s, generators no longer relied on a ground reference, which reduced the risk of unintentional current flow through alternative pathways that could potentially result in a thermoelectrical burn [7].

Monopolar electrosurgery is widely employed due to its versatility and efficacy. In this technique, a pencil-like instrument is utilized, with the active electrode positioned at the entry site. This configuration allows for both tissue cutting and hemostatic coagulation. The return electrode pad is affixed to the patient, facilitating the flow of electrical current from the generator to the active electrode, through the targeted tissue, and back to the generator via the return pad. Current density is high at the working electrode but low at the much larger return or dispersive electrode. If the contact area of the return electrode unintentionally decreases, the risk of a pad-site burn increases.

Contact Quality Monitoring (CQM) systems were incorporated into generators by the end of the century to help decrease the chances of a pad-site burn. CQM measures the resistance of a two-part electrode. If the contact area decreases, resulting in increased resistance, an alarm sounds notifying the user of a dangerous situation. [8, 9] Another method of mitigating the inherent risks of an adhesive pad electrode is to use a contactless device that relies on capacitive coupling, such as the Mega Soft pad. [10] This device is designed to limit the current density passing through it, reducing the risk of a pad-site burn.

Monopolar electrosurgery generators have two basic waveforms called Cut and Coagulation (Coag). The Cut waveform is a continuous waveform at a constant voltage and is used for quickly cutting through tissue with little hemostasis. The Coag waveform is intermittent with much higher voltage that provides greater hemostasis. Over time, generators have incorporated additional settings, such as blends of Cut and Coag, as well as modifications for specific applications like spray, fulguration, and soft coagulation. [11] More advanced monopolar waveforms have continued to be developed. Geometric Electrode Modulation (GEM) maintains a constant, optimal voltage by sensing tissue impedance and

adjusting power to hold the voltage constant, without requiring power adjustments throughout the procedure. The constant voltage allows the user to cut through different tissue types with minimal thermal damage [11, 12].

For basic bipolar electrodes, two energy modes, micro and macro, provide precise or rapid application, respectively. Further advances have been made in generator technology both for bipolar and ultrasonic devices. Advanced bipolar electrodes, which generally include their own dissecting blade, are powered by sophisticated algorithms, such as Adaptive Tissue Technology. [13] The generator monitors the electrical impedance of the tissue and modifies the voltage applied to optimize hemostasis.

Ultrasonic devices depend upon mechanical action, powered by an electrical waveform, to both coagulate and cut tissue. The Adaptive Tissue Technology monitors the resonant frequency of the ultrasonic blade to evaluate tissue characteristics, and modifies the power to optimally seal and then cut vessels up to 5 mm in diameter. [14] Further advances in the generator algorithm led to an Advanced Hemostasis mode, which enables the sealing of vessels up to 7 mm in diameter [15, 16].

Recently, a new generator, the Dualto Energy System (Figure 1) has been developed. This generator combines core electrosurgery capabilities with enhanced monopolar, bipolar, advanced bipolar, and ultrasonic technologies in a user-centric interface. Moreover, the Dualto has a modular design, allowing multiple electrodes to be used simultaneously in a single unit, which has previously been unavailable. This study was undertaken to evaluate the operation of Dualto using individual modes and in combination of modes. Benchtop and preclinical testing was performed to validate sealing and transection capabilities. In addition, surveys were conducted with operating room staff to gauge the system's overall usability and estimate potential cost-savings by switching from individual energy systems to the new Dualto.



Figure 1. The Dualto Energy System with a single energy module.

2. Methods

All *in vivo* procedures were reviewed and animals approved for use by the Ethicon Institutional Animal Care and Use Committee in compliance with the US Animal Welfare Act Regulations (9CFR, Parts 1, 2 & 3) and the Guide for the Care and Use of Laboratory Animals of the Association for Assessment and Accreditation of Laboratory Animal Care, International (AAALAC).

The instruments and devices evaluated in this study, including the DUALTO™ Energy System, the MEGADYNE™ Electrosurgical Generator (MEGEN1), the Ethicon GEN11 Generator (GEN11), MEGADYNE Telescoping Smoke Evacuation Pencil, ENSEAL™ X1 Large Jaw (NSLX120L) and Curved Jaw Tissue Sealer (NSLX137C), and HARMONIC FOCUS™+ Long Shears (HAR17F), HARMONIC ACE+ Shears (HARH36), and HARMONIC 1100 Shears (HAR1136), are distributed by Johnson & Johnson MedTech, Cincinnati, OH.

2.1. Benchtop

Advanced Bipolar and Harmonic ultrasonic devices were used to seal and transect *ex vivo* porcine carotid arteries [1-7 mm in diameter] and evaluate hemostasis performance by measuring the pressure at which the seal bursts, using both the Dualto and GEN11 generators. The Advanced Bipolar devices were Enseal Large Jaw Tissue Sealer NSLX120L and Enseal Curved Jaw Tissue Sealer NSLX137C. The Harmonic ultrasonic devices were Focus+ HAR17F, ACE+7 HARH36, and Harmonic 1100 HAR1136.

Thermal effects on tissue were assessed for both monopolar and bipolar modes using the Dualto generator and the MEGEN1 generator to compare the thermal spread between the two devices. *Ex vivo* porcine kidney, liver, and muscle tissues were utilized for this evaluation. Each mode was tested at three different power settings: Minimum, Representative Default Setting, and Maximum. The electrodes used for monopolar were selected based on the mode (i.e., spatula for Cut modes, ball coagulator for Coag modes) while for bipolar a set of standard forceps was used. Additionally, the GEM mode was also evaluated as monopolar.

2.2. Waveform & Energy Analysis

Testing of generator isolated current was conducted in both *ex vivo* and *in vivo* models to show that two Dualto Energy System generators in the Expanded (double energy module) configuration operate as electrically isolated systems when both monopolar outputs are activated at the same time.

In the Expanded Configuration using two energy modules, both modules were activated simultaneously, and the waveforms of the output and return electrodes for each module in monopolar mode were examined to ensure that the output waveform corresponded with the return waveform for each

module. Additionally, the magnitude of the current on the output electrode was compared to the current measured on the return electrode for each module.

Transection speed for ultrasonic usage was assessed by first measuring the time frequency lock, which is the time needed for the generator to achieve the resonant frequency prior to the application of therapeutic energy delivery. Frequency lock time was measured for Focus+, Harmonic 700, and Harmonic 1100 when applied to porcine mesenteric root (a thick, fibrotic tissue of the mesentery attached to the posterior abdominal wall), or thick synthetic chamois (No. 506, Zymöl, Brooksville, FL) soaked in normal saline. Transection speed was then determined by applying Harmonic 700 to mesentery and Focus+ to chamois cloth. Both measurements were performed with GEN11 and Dualto generators. The median or mean was compared between the generators for the frequency lock and transection speed for Harmonic 700 and Focus+, and the rate of prolonged transection (i.e., longer than 5.5 seconds) for Focus+.

2.3. Preclinical

Two acute animal studies were conducted comparing Dualto Generator systems in Single and Expanded configurations against GEN11, using Enseal (NSLX120L, NSLX137C) or Harmonic (HAR17F, HARH36, HAR1136) devices. First pass hemostasis, the state of hemostasis after pharmacologically induced hypertensive crisis, and maximum lateral thermal damage were assessed. In the Expanded configuration, an Advanced Bipolar/Ultrasonic device was used to seal vessels on one of the energy modules, while a Monopolar pencil was used simultaneously on the second energy module to complete dissection tasks.

Three chronic animal studies were conducted to evaluate the performance of the Dualto. Two chronic animal studies were conducted to evaluate hemostasis performance and healing of a Single Configuration Dualto system using Advanced Bipolar (NSLX120L) or Ultrasonic (HAR17F, HARH36, HAR1136) devices was studied. Chronic seal durability was assessed at 28 ± 5 days post operatively.

The third chronic animal study was performed to assess the potential tissue effects at the return electrode contact site (e.g., skin burns) of the Dualto in the expanded configuration, compared to the MEGEN1, when utilized in monopolar mode. Tissue effects were evaluated at the skin in contact with and surrounding the return electrode pad at the following timepoints: 1. Prior to surgery; 2. After closing surgical incisions; 3. During the survival period starting at day 1 until 7 (+1) days postoperatively.; 4. At post-mortem (7 [+1] days) during necropsy gross assessment. Three systems were compared: 1. A single MEGEN1 generator with a single monopolar pencil; 2. Two MEGEN1 generators activated at the same time with a monopolar pencil connected to each generator; 3. A Dualto generator in expanded configuration with two monopolar pencils activated simultaneously. All

systems were tested with Cut mode at 150 and 70 W and Coag mode at 120 and 60 W. These are high values that may be used clinically. Each system evaluated an adhesive and a capacitive return electrode. The highest power settings were used for Dualto in the expanded configuration.

2.4. Survey

Surveys were conducted with three user groups: surgeons, nurses, and biomedical technicians (biomeds), following their participation in Human Factors Validation, Summative Usability, or Design Validation evaluations, respectively. Each group was asked about their agreement/disagreement concerning a series of statements relative to their function after exposure to the Dualto.

2.5. Acquisition Cost

An acquisition cost calculator was developed to estimate the cumulative impact on cost based on the following variables: equipment cost of energy generator, annual service cost of energy generator, operating Room (OR) use, and biomed/clinical engineer time. Values for the operating room time setup, troubleshooting, and biomed time were based on results from the survey.

2.6. Statistics

The burst pressure of the Advanced Energy devices when activated on the Dualto was compared to that of the GEN11 and tested for non-inferiority at a 95% confidence level for a

mean difference of no more than 200mmHg, a customary value based on historical values of the standard deviation.

In the acute studies, for first pass hemostasis and hemostasis after simulated hypertensive crisis, the rate for the Dualto group was tested for non-inferiority (defined by a 10% margin for the difference at 90% confidence for the proportion) to the rate for GEN11 group. The lateral thermal damage for the Dualto group was tested for comparability (non-inferiority of the ratio of means not exceeding 125% at 90% confidence for the proportion) to the GEN11 group.

In the chronic studies, hemostasis at initial transection (first pass hemostasis) was tested against a criterion of either 100% hemostasis or not significantly higher incidence of failures than the historical control article via Fisher's exact test. Chronic seal durability was evaluated against a criterion of 100% hemostasis, after definitive evaluation via histopathology. Any seal failures that were identified to be independent of the device performance were excluded from the assessment.

3. Results

3.1. Benchtop

The mean vessel burst pressure of Advanced Energy devices, both Enseal and Harmonic, on the Dualto generator was non-inferior to use on the GEN11 generator at the 95% confidence level using a margin of non-inferiority of 200 mmHg (Table 1).

Table 1. Advanced Energy Burst Pressure Comparisons.

Device	Dualto Generator	GEN11 Generator	p-value non-inferiority
Enseal X1 Large Jaw NSLX120L	659.9 ± 398.1 mmHg (n=215)	704.5 ± 416.2 mmHg (n=215)	<0.001
Enseal X1 Curved Jaw NSLX137C	972.8 ± 382.0 mmHg (n=215)	999.7 ± 421.2 mmHg (n=215)	<0.001
Harmonic Focus + HAR17F	811.7 ± 398.9 mmHg (n=216)	758.6 ± 400.2 mmHg (n=214)	<0.001
Harmonic ACE+7 HARH36	973.6 ± 427.7 mmHg (n=213)	917.3 ± 450.5 mmHg (n=214)	<0.001
Harmonic 1100 HAR1136	1070.7 ± 471.6 mmHg (n=211)	1034.2 ± 451.8 mmHg (n=217)	<0.001

For bipolar instruments, there was comparable thermal spread between generators. For monopolar instruments, there was also substantially comparable thermal spread between generators. However, the Cut Pure and Blend modes at the maximum power setting (Cut mode at 150 W and Coag mode at 120 W) exhibited slightly higher thermal spread for Dualto compared to MEGEN1. This was attributed to the Dualto device's ability to maintain constant power across higher resistance values for the Cut Pure and Blend modes compared

to the MEGEN1. In GEM mode, monopolar instruments exhibited comparable thermal spread between Dualto and MEGEN1.

3.2. Waveform & Energy

Visual analysis confirmed that the output and return waveform for each generator in Expanded Configuration match when the generators are activated simultaneously.

Linear relationships between the current measurements on the output and return electrode for each generator demonstrated that the monopolar output electrode current returned to its own generator through its respective return electrode.

Mean frequency lock time for Dualto was 50% shorter than

for GEN11, i.e., Dualto was twice as fast to establish the resonant frequency prior to therapeutic energy delivery (Table 2). Overall transection times were 15-22% faster, and there were 71% fewer prolonged (>5.5 s) transections for Dualto compared to GEN11.

Table 2. Frequency Lock and Transection Speed for Harmonic devices.

Measure	Harmonic Device	GEN11	Dualto	p-value
Frequency Lock				
Median	Focus+, 700, 1100	0.30 s	0.11 s	<0.001
Mean $\pm$ St Dev		0.266 $\pm$ 0.050 s	0.133 $\pm$ 0.037 s	
Transection Speed				
Mean $\pm$ St Dev	700	5.04 $\pm$ 1.08 s	4.12 $\pm$ 0.93 s	0.001
Median	Focus+	5.39 s	4.67 s	0.007
Prolonged Transection Time	Focus+	46.7% (14/30)	13.3% (4/30)	0.010

3.3. Preclinical

In the acute studies, the single and expanded configuration

of the Dualto was non-inferior to the GEN11 for first pass hemostasis, hemostasis after simulated hypertensive crisis, and lateral thermal spread for both the Advanced Bipolar and Ultrasonic modalities (Table 3).

Table 3. Generator Confirmatory Acute Testing Results.

Device	Test	GEN11	Dualto Single Config	Dualto Expanded Config
Advanced Bipolar (Enseal NSLX120L, NSLX137C)	First Pass Hemostasis	100% (227/227)	99.6% (222/223)	100% (226/226)
	Blood Pressure Challenge	100% (227/227)	99.6% (222/223)	99.6% (225/226)
	Lateral Thermal Damage	2.29 $\pm$ 0.56 mm	2.22 $\pm$ 0.38 mm	1.97 $\pm$ 0.33 mm
Ultrasonic (Harmonic HAR17F, HARH36, HAR1136)	First Pass Hemostasis	99.6% (222/223)	99.5% (220/221)	99.6% (224/225)
	Blood Pressure Challenge	98.6% (219/222)	98.6% (217/220)	98.7% (221/224)
	Lateral Thermal Damage	2.05 $\pm$ 0.44 mm	1.95 $\pm$ 0.40 mm	1.89 $\pm$ 0.34 mm

Table 4. Generator Confirmatory Chronic Testing Results.

Device	Test	Dualto
Advanced Bipolar (Enseal X1 NSLX120L, NSLX137C)	First Pass Hemostasis	100% (171/171)
	Chronic Seal Durability	100% (171/171)
Ultrasonic (Harmonic HAR17F, HARH36, HAR1136)	First Pass Hemostasis	99.2% (245/247)
	Chronic Seal Durability	99.6% (232/233)

In the chronic studies, the Dualto met the success criteria for first pass hemostasis at initial transection and chronic seal durability for the Advanced Bipolar modality (Table 4). For the Ultrasonic modality, the Dualto met the success criteria for first pass hemostasis at initial transection. A chronic durable seal was established in all but one caudal carotid artery of one animal resulting in 99.6% hemostasis success, which is not significantly lower than historical predicates.

The evaluation of monopolar electrosurgery demonstrated an overall comparable outcome at the skin in contact with and surrounding the return electrode pad for Dualto in the expanded configuration compared to the MEGEN1. Evidence of tissue effects (including thermal damage) with either the adhesive or the capacitive return electrodes was not present in any of the animals in both groups.

3.4. Survey

Dualto was evaluated by surgeons (n=33), nurses (n=23), and biomed (n=15) to gauge its usability and effectiveness. Overall, participants agreed that Dualto provided benefits and improved surgical tasks compared to current systems on the market.

Biomed generally expressed positive views on Dualto. They believed the system could significantly save time during output verification and annual maintenance compared to existing systems, with anticipated cost reductions in annual maintenance, service, and repairs due to the consolidated system.

Nurses believed Dualto could improve OR efficiency through faster setup times, reduced downtime due to troubleshooting, and a more streamlined user interface. They thought the system might reduce stress levels for medical staff by simplifying the user experience, improving intraoperative diagnostics, and minimizing incorrect power settings. Nurses found Dualto easier to use compared to current systems, and provided greater surgical flexibility compared to other generators on the market.

Surgeons generally expressed positive views about Dualto. They identified factors impacting OR efficiency, including extended setup time, equipment availability, and downtime due to troubleshooting. They believed that Dualto, with its streamlined setup and surgeon profiles, could improve OR efficiency. Surgeons agreed that a streamlined setup and reduced downtime could minimize stress levels for both themselves and the clinical team. Most of the surgeons agreed that Dualto provides more surgical flexibility compared to other generators on the market and that the combined system could potentially reduce training time compared to other individual systems.

3.5. Acquisition Cost

As an example of the potential cost savings involved in acquiring the Dualto compared to an alternative generator, the following scenario was used to estimate costs over a ten-year period: one OR, 5 procedures/day/device or 1200 procedures/year, 70 mins average procedure time [17], 50% of cases

requiring troubleshooting. Based on surgeon responses from the survey, Dualto saved on average 4.1 min/case through improved troubleshooting guidance, and 3.4 min on average during case setup. This yields an average OR time saving of 27.1 min/day, in addition to 13.3 min of biomed time saved per year on average for output verification. Assuming an average OR time cost of \$24.83/min [18] and a biomed cost of \$0.48/min [19], this could lead to annual savings of up to \$161,292, despite the higher upfront capital purchase price of Dualto compared to the alternative in the first year.

4. Discussion

This study evaluated the performance and usability of the Dualto Energy System, a new electrosurgical generator consolidating multiple energy modalities into a single, modular platform. Our findings demonstrate that Dualto exhibits comparable or improved performance compared to existing individual energy systems across various benchtop, preclinical, and user-based assessments.

Benchtop testing confirmed the non-inferiority of Dualto for vessel sealing and transection using both Advanced Bipolar (Enseal) and Ultrasonic (Harmonic) devices compared to the GEN11 generator. While some slight differences in thermal spread were observed in specific monopolar modes at maximum power settings, higher power settings than those typically used in clinical practice, these were attributed to Dualto's ability to maintain constant power across varying tissue impedance, potentially offering more consistent energy delivery. Importantly, the GEM mode on Dualto demonstrated comparable thermal spread to the MEGEN1. These results suggest that Dualto can effectively deliver energy across different modalities.

The waveform and energy analysis validated the electrical isolation of the Dualto generators in the Expanded configuration, showing that simultaneous use of multiple monopolar outputs does not create unintended current pathways. This is crucial for patient safety during procedures requiring multiple energy sources. Furthermore, the significantly shorter frequency lock time and faster transection speeds observed with the Harmonic devices on Dualto compared to GEN11 suggest potential improvements in procedural efficiency, especially when performing marching (i.e., sequential firing), for example, along the mesentery. The reduction in prolonged transections with Dualto further reinforces this potential benefit.

Preclinical studies corroborated the benchtop findings, demonstrating non-inferior hemostasis at first-pass, hemostasis after pharmaceutically induced hypertensive crisis, and comparable lateral thermal spread for both Advanced Bipolar and Ultrasonic modalities on Dualto compared to GEN11. Chronic studies confirmed first-pass hemostasis and chronic seal durability for both modalities, meeting pre-defined success criteria. The chronic monopolar evaluation demonstrated

comparable tissue effects at the return electrode site for Dualto in the Expanded configuration compared to MEGEN1, with no evidence of thermal damage observed.

User surveys revealed positive feedback regarding the usability and potential benefits of Dualto. Biomedical technicians anticipated significant time savings in equipment verification and maintenance, translating to potential cost reductions. Nurses highlighted potential improvements in OR efficiency through faster setup times, reduced downtime, and a more streamlined user interface. Surgeons echoed these sentiments, emphasizing the potential for improved OR efficiency, reduced stress levels, and increased surgical flexibility.

The acquisition cost analysis further illustrates the potential economic benefits of switching to Dualto, which has specific improved functionality for set up and troubleshooting guidance (interface and advanced functions). By consolidating multiple devices and streamlining OR procedures, Dualto can lead to cost savings through reduced OR time, decreased maintenance costs, and optimized resource utilization. These cost savings during use can help to offset the initial capital expenditure, and the modularity of the design has been shown to lessen overall costs relative to the purchase of individual generators.

An important benefit of having a combination generator that provides both basic and advanced electrical and mechanical surgery support in a single unit is the reduction in the use of valuable operating room space (Figure 2). When using the Dualto in expanded configuration, compared to two MEGEN1 and two GEN11 generators in side-by-side configuration, there is a 26% reduction in volume and a 70% reduction in footprint.

One of the key advantages of the Dualto generator is its ability to integrate multiple functions into a single unit. In contrast, traditional surgical setups often necessitate a range of specialized instruments, each accompanied by its own tower unit as the generator. This fragmentation is evident when performing various tasks, such as utilizing monopolar and bipolar capabilities or incorporating ultrasonic energy devices. By adopting the multifunctional Dualto, surgeons can reduce the number of generators needed during a procedure. This consolidation not only streamlines the surgical workflow but also mitigates the challenges associated with managing numerous instruments, thereby contributing to a more organized and efficient operating room.

Two energy modules are especially helpful during procedures where two surgeons operate at the same time using energy devices, such as in oncological surgeries where both oncologists and plastic surgeons might be involved, or open-heart surgery where one surgeon harvests the vein for a bypass while the other surgeon prepares the heart for the graft. Multifunctional generators can facilitate this by providing the necessary energy modalities—such as diathermy, ultrasonic energy—in one device.

Moreover, space in the OR is a key factor, especially in procedures that require the participation of several surgical teams. The presence of a single, multifunctional energy de-

vice can free up space, allowing for better maneuverability for the surgical team.

Limitations: This is the first benchtop study of the Dualto Energy System, so it is necessarily limited by lack of long-term clinical data. Further, the testing was performed on a single-brand device without comparison to other commercial products.



Figure 2. The Dualto Energy System with two energy modules, cart and foot pedals.

5. Conclusion

The Dualto Energy System represents an advancement in electrosurgical technology. Our findings demonstrate that Dualto offers comparable or improved performance across various energy modalities, while also providing benefits in terms of usability, efficiency, and potential cost savings. The consolidated, modular design of Dualto addresses the growing need for streamlined and versatile energy solutions in the modern operating room. These results suggest that Dualto has the potential to be a useful tool in the operating room, helping the staff in their quest to optimize healthcare resource utilization.

Abbreviations

CQM	Contact Quality Monitoring
GEM	Geometric Electrode Modulation
AAALAC	Association for Assessment and Accreditation of Laboratory Animal Care, International
OR	Operating Room

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Madeleine Clark Jayme: Conceptualization, Data curation, Formal Analysis, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing

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Conflicts of Interest

All authors were employees of Johnson & Johnson Medtech, manufacturer of the Dualto Energy system.

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