DE NOVO CLASSIFICATION REQUEST FOR
MEDTRONIC NEUROSURGERY DUET™ EXTERNAL DRAINAGE AND MONITORING SYSTEM (EDMS)

REGULATORY INFORMATION

FDA identifies this generic type of device as:

> **Cerebrospinal fluid shunt system.** A cerebrospinal fluid shunt system is a prescription device used to monitor and divert fluid from the brain or other part of the central nervous system to an internal delivery site or an external receptacle for the purpose of preventing spinal cord ischemia or injury during procedures that require reduction in central nervous system pressure. A cerebrospinal fluid shunt system may include catheters, valved catheters, valves, connectors, and pressure monitors intended to facilitate use of the shunt or evaluation of a patient with a shunt.

NEW REGULATION NUMBER: 21 CFR 882.5560

CLASSIFICATION: Class II

PRODUCT CODE: PCB

BACKGROUND

DEVICE NAME: Medtronic Neurosurgery DUET™ External Drainage and Monitoring System (EDMS)

DE NOVO REQUEST: DEN120017

DATE OF DE NOVO REQUEST: December 21, 2012

REQUESTER CONTACT: Medtronic Neurosurgery
125 Cremona Drive
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INDICATIONS FOR USE

The DUET™ EDMS is indicated for temporary draining and monitoring of cerebrospinal fluid (CSF) flow from the lumbar subarachnoid space in:

1. Patients undergoing open descending thoracic aortic aneurysm (open TAA) or open descending thoraco-abdominal aortic aneurysm (open TAAA) repair surgery.
2. Patients post TAA/TAAA repair that become symptomatic with neurological deficit such as paraplegia.

LIMITATIONS

For prescription use only.

The use of a DUET™ EDMS lumbar catheter for drainage and monitoring of cerebrospinal fluid from the lumbar subarachnoid space is contraindicated in a patient with:

- non-communicating hydrocephalus;
- large intracranial mass lesions, tumors, hematomas, or cysts;
- infections in the area surrounding the lumbar puncture which includes the skin, subcutaneous tissue, bone and the epidural space; or
- demonstrated blockage of cerebrospinal fluid to the subarachnoid space due to trauma, hematoma, fracture or tumor.

The use of a DUET™ EDMS requires 24-hour-a-day availability of trained personnel to supervise monitoring and drainage.

Literature suggests a maximum CSF drainage duration of 3 days for aneurysm repair patients who do not exhibit symptoms of neurological deficit, with longer durations for those exhibiting symptoms; however, drainage duration should be at the medical discretion of the physician and based on the institution's protocol.

Warnings & Precautions:

- It is possible that the puncture of the ventricle or the opening of the dura will result in an intracranial hemorrhage.
- It is possible that if too much CSF is removed from the ventricles, either during a drainage procedure or when the ventricle is first punctured, the ventricle may collapse and occlude the catheter.
- It is possible that the monitoring system may give a false pressure reading either due to a pressure line becoming clogged or kinked or from an air bubble lodged in the system. An incorrect pressure reading may lead to the wrong therapy being given to the patient. The irrigation of the catheter or the performance of a Volume Pressure Relationship (VPR) study may induce pressure waves in the patient. For this reason, irrigation or VPR studies should be done only by, or on the order of, a physician.
- In order to minimize the possibility of infection, meningitis or ventriculitis, several steps should be observed. First, the injection sites should always be cleaned with alcohol and the alcohol allowed to dry before a needle is inserted into them. Second, sterile technique should be observed in setting up the system and in the placement of the catheter. Third, subgaleal tunneling of the ventricular catheter should be approximately one to two inches.
- Leakage from the system, which can result from damaged system components or improper use of handling, can potentially result in over-drainage, the need to replace the drainage system and/or other complications to the patient.
- In order to ensure against ventricular collapse and the possible consequences of tentorial herniation, always perform a drainage maneuver against a positive

pressure head on the order of 20 cm H2O or 15 mmHg. In addition, when the ventricle or lumbar subarachnoid space is first punctured during the insertion of the catheter, care should be taken so as little CSF as possible is lost.

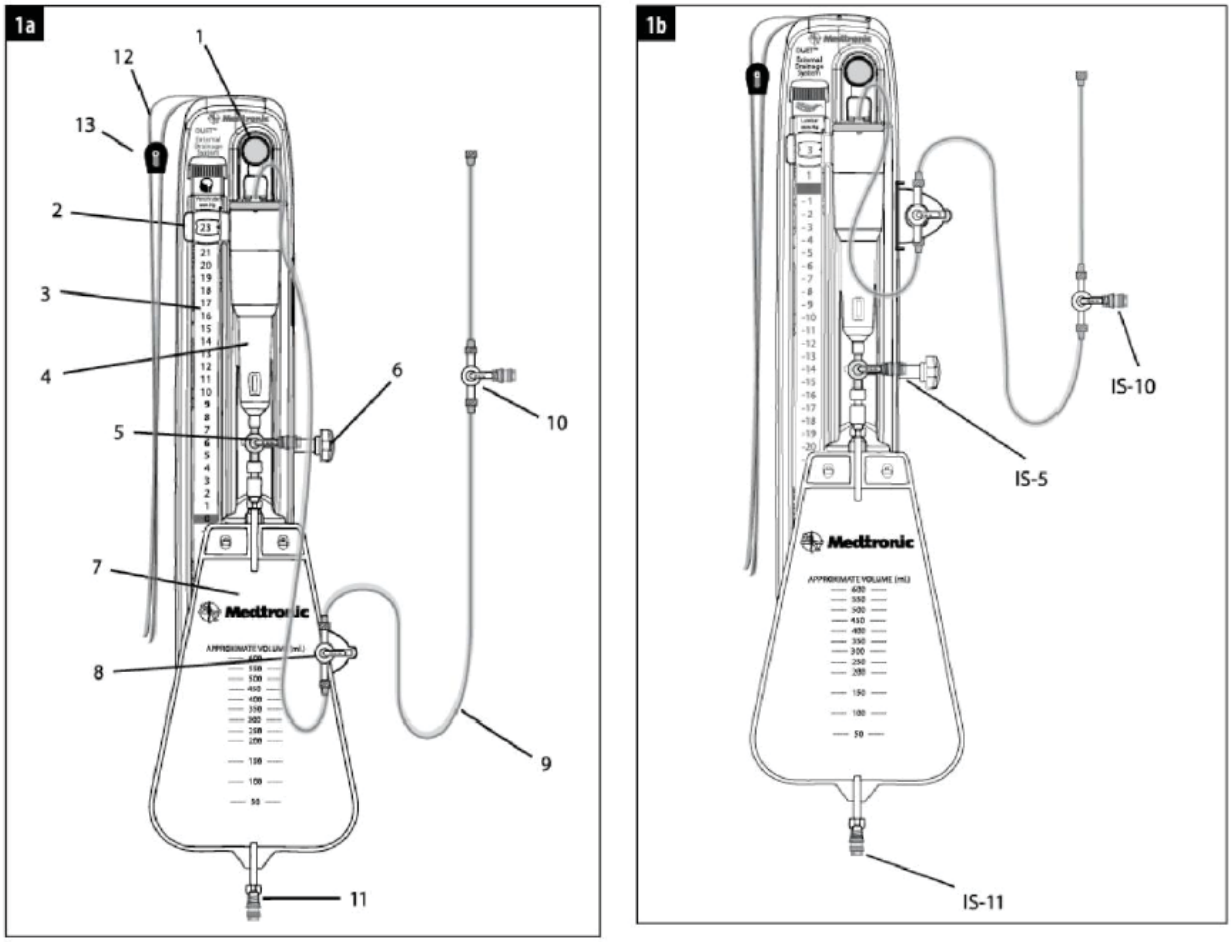
- Whenever irrigation of the catheter or the performance of the VPR is decided upon, great care must be used so that pressure waves are not initiated. Only a small volume of saline should ever be injected into the ventricular system, and this only done by, or on the order of, a physician. In general, in monitoring intracranial pressure, one should always be aware of the waveform on the oscilloscope. If the waveform begins to dampen out, it is important that the entire monitoring system be examined. Ensure that the line to the patient is not kinked and that all air bubbles or blood or other debris are removed from the system. Ascertain that the transducer is on the same level as the patient's ventricular system to ensure the proper reference level in the manometer tube for use in calibration procedures. Pressure monitoring with the manometer may result in over-drainage of the ventricles.
- Improper vigilance or improper drainage system setup can lead to over- or under-drainage and potentially serious injury to the patient. Intracranial and lumbar pressure monitoring has been associated with intracranial infection, meningitis and ventriculitis. This hazard has been quoted at less than 1% to more than 5%. The risk of infection is probably influenced both by the number of times a system is opened and by the duration of the monitoring. Prolonged steroid therapy can also increase the risk of infection.

DEVICE DESCRIPTION

The Medtronic DUET™ External Drainage and Monitoring System (EDMS) that is the subject of this De Novo request is designed to drain and monitor cerebrospinal fluid (CSF) from the lumbar subarachnoid space.

The DUET™ EDMS consists of the following: a green-striped patient connection line (pressure tubing) with an inner diameter of 0.075 ± 0.005 inches, an outer diameter of 0.124 ± 0.003 inches, and a total length of 60 inches (9), a patient line stopcock (10), a main system stopcock (8) that may be attached at two locations on the main panel, a drip chamber (4) with a drip chamber stopcock (5), a rotatable pressure scale (3), three latex-free needleless injection/CSF sampling sites (Figure 1b (IS-5), (IS-10) and (IS-11)) and a removable drainage bag (7) with approximate volumetric graduations and a hydrophobic microbial barrier air vent. There is a pole mount clamp (6) and a cord (12) with a cord lock (13) to enable independent suspension of the system, or to provide additional security when using the pole clamp as identified in Figure 1 below. It should be noted that the numbers in parentheses correspond with the numbers in Figure 1.

Figure 1: Medtronic DUET EDMS (a) and Location of Injection/CSF Sampling Sites (b)



The DUET™ EDMS are not long-term implants but are intended for limited external drainage of CSF. The drainage flow of CSF into the DUET™ EDMS is uni-directional and gravity-driven; there is no recirculation of the CSF. During use, an external lumbar catheter inserted into the lumbar subarachnoid space is connected to the DUET™ EDMS patient connection line. The CSF drains through the catheter, into the patient connection line and into the graduated drip chamber. CSF collects in the drip chamber, exits the bottom of the chamber via another connection line and is collected in a drainage bag. In the event that the patient may require administration of fluid directly into the lumbar subarachnoid space or CSF sampling is required, the DUET™ EDMS features injection/CSF sampling ports integrated into the patient connection line. The DUET™ EDMS is completely disposable. The DUET™ EDMS is recommended for use with the Clear-Site™ Laser Level (cleared under K984053) that is provided separately.

SUMMARY OF NONCLINICAL/BENCH STUDIES

The non-clinical/bench studies conducted on the DUET™ EDMS to demonstrate the safety and effectiveness of the device are summarized in the sections below. The technological characteristics of the DUET™ EDMS for the subject De Novo is identical to the system cleared in K984053.

BIOCOMPATIBILITY/MATERIALS

The components of the patient lines in the DUET™ EDMS were tested for biocompatibility because these patient lines have the potential for contact with CSF that could be re-introduced to the patient in the case of retrograde flow. The patient lines are classified as external communicating devices of limited contact duration (< 24 hours). The biocompatibility tests conducted on the patient lines of the DUET™ EDMS are shown in Table 1.

TABLE 1: DUET EDMS™ PATIENT LINE BIOCOMPATIBILITY TESTING

Test	Purpose	Acceptance Criteria	Results
Cytotoxicity (MEM Elution)	Determine the lysis of cells (cell death), the inhibition of cell growth, and other effects on cells caused by the device, materials and/or other extracts.	Meets requirements in ISO 10993-1: 2009/(R)2013	Non-Cytotoxic
Sensitization (Saline, Sesame Oil (SO))	Estimate the potential for contact sensitization of the device, materials and/or other extracts.	Meets requirements in ISO 10993-1: 2009/(R)2013	Non-Sensitizer
Intracutaneous Reactivity (Saline, SO)	Evaluate the local dermal irritant or toxic effects of leachables extracted from the test article following intracutaneous injection in rabbits.	Meets requirements in ISO 10993-1: 2009/(R)2013	Non-Irritant
Acute Systemic Toxicity	Estimate the potential harmful effects of either single or multiple exposures, during a period of less than 24 hours, to devices, materials and/or extracts.	Meets requirements in ISO 10993-1: 2009/(R)2013	No Acute Systemic Toxicity, Biocompatible Materials

SHELF LIFE/STERILITY

The DUET™ EDMS is labeled with a 3 year shelf-life. Table 2 contains a summary of the shelf-life testing conducted on the DUET™ EDMS and its packaging after 3 years and one month of real-time aging and ethylene oxide sterilization to validate the 3 year expiration date. All shelf-life testing, which included both functional and package integrity testing, passed the corresponding acceptance criteria.

TABLE 2: DUET™ EDMS SHELF-LIFE TESTING

DUET System
Main System Stopcock (MSS) assembly to attachment arm: MSS assembly must not be displaced or dislodged with 5 in-lbs torque applied to arm of stopcock.
Main System Stopcock (MSS) assembly to attachment arm: MSS assembly must not be displaced or dislodged with a 5 lb load applied downward onto the core of the stopcock arm.
Clamp to maintain secure attachment of device to 0.75"-1.25" diameter pole with 5 pound load in the downward axial direction for a minimum of 1 minute with 3 in-lbs torque applied to the pole clamp thumb screw.
Drip chamber/bag subassembly to panel: Subassembly to remain stationary with 3.5 pound load applied in the axial direction with 3 in-lb torque applied to thumbscrew used to secure subassembly to panel.
Attachment of junctions - tubes to luers: Must withstand minimum 5 pound load in the axial direction.
Attachment of junctions - stopcock to drip assembly: Must withstand minimum 5 pound load in the axial direction.
Stopcock/bottom cap junction: The Stopcock/Bottom cap Bond shall withstand 3.1 in-lbs torque when tested per TM-488-QA.
Drip assembly and drainage bag vent integrity: Vents must withstand 150 mm Hg fluid pressure.
Drip assembly vent integrity: With Main System Stopcock closed relative to the drip assembly, vent must allow withdrawal of 30 mL distilled water from the bottom of the drip chamber in 15 seconds without compromising the mechanical integrity of the vent.
Leakage of UV-cure bonds (Patient line & Drip Chamber subassembly): bonds to withstand 200 mmHg of air with no more than 0.5cc/min of leakage.
Cord to I.V. pole: Cord and cord lock to maintain secure hanging of system with 5 pound load in the downward axial direction for a minimum of 1 minute.
Drip assembly and drainage bag vent integrity: Vents must withstand 150 mm Hg fluid pressure.
Tensile strength of drainage bag inlet port: 10 lbs. minimum in axial direction.
Disposable drainage bag seal weld: No leak at 1 psi.
Flow initiation pressure of drainage bag (includes anti-reflux valve): units must initiate flow by 15 cm water.
Leakage of drainage bag: bag must withstand being inverted with 700 mL of fluid with no more than 2 mL of leakage after one minute.
Drip assembly vent: with vent wet with a mixture of 10% blood and 90% lactated Ringer's solution for 30 minutes at 50 mmHg fluid pressure, vent must: • allow drainage of 30 mL of blood and Ringer's solution mixture within 3 minutes • provide CSF flow through system of no more resistance than +2.2 cm water at an inflow rate of 20 mL/hour after drainage of blood and Ringer's solution mixture
Packaging
Shipping - Product packaging and contained product must be secure, undamaged, and must meet all specifications after simulated shipping conditions per ISTA-2A and simulated shelf life conditions. (Dye Penetration Test and Bubble Leak)
Shipping - Product inspection method: visual

The package integrity testing for the DUET EDMS conforms to the following FDA recognized consensus standards:

- AAMI ANSI ISO 11607-1:2006/(R)2010 – Packaging for Terminally Sterilized Medical Devices – Part 1: Requirements for Materials, Sterile Barrier Systems, and Packaging Systems

- AAMI ANSI ISO 11607-2:2006/(R)2010 – Packaging for Terminally Sterilized Medical Devices – Part 2: Validation Requirements for Forming, Sealing and Sealing Processes Standards

- ASTM F1886 – Standard Test Method for Determining Integrity of Seals for Flexible Packaging by Visual Inspection

- ASTM F2096 – Standard Test Method for Detecting Gross Leaks in Medical Packaging by Internal Pressurization (Bubble Test)

- ASTM F88/F88M-09 – Standard Test Method for Seal Strength of Flexible Barrier Material

The DUET™ EDMS is sterilized by 100% ethylene oxide (EO) with a validated Sterility Assurance Level (SAL) of 10^{-6}. The device is indicated for single use only and disposable. The sterilization validation for the DUET™ EDMS is in compliance with ISO 11135-1:2007 and ISO 10993-7:2008 with no deviations. In addition, endotoxin testing using the limulus amebocyte lysate (LAL) method was conducted on the fluid path of the DUET™ EDMS to meet the endotoxin limit of 2.15 EU/device per USP <161>.

Material-mediated pyrogenicity testing was also conducted on the DUET™ EDMS to detect material-mediated pyrogenic reactions of extracts of the device and/or materials. The testing meets the requirements in ISO 10993-1: 2009/(R)2013. The results show that the extracts of the device and/or its materials are non-pyrogenic.

PERFORMANCE TESTING – BENCH

The DUET™ EDMS was tested and passed the following performance (bench) tests listed in Table 3.

TABLE 3: DUET™ EDMS PERFORMANCE TESTS

Test Name	Test Method
Dimensional	Measure the dimensions of the scale label vertical and horizontal alignment, pressure scale lengths, patient line tubing inner diameter (ID) and length, cord length, drainage path ID (from bottom of drip chamber), and stopcock flow path diameter.
Drip Chamber Graduations	Verify the correct readings on the drip chamber graduation.

Main System Stopcock (MSS) Assembly Torque Applied to Arm of Stopcock	Record the peak torque at which the MSS assembly fails or detaches from the panel.
MSS Assembly Load Applied to Core of Stopcock Arm	Record peak load at which MSS assembly failed.
Clamp to I.V. Pole Attachment Strength	Ensure secure attachment of clamp to I.V. pole.
Cord to I.V. Pole Attachment Strength	Ensure cord and cord lock maintains secure hanging of system.
Drip Chamber to Back Panel Attachment Strength	Ensure secure attachment of drip chamber/bag subassembly to panel.
Strength of Attached Junctions (i.e., Tubing to Luer)	Ensure secure attachment of junctions of tubes to luer.
Bottom Cap to Stopcock Junction Torque	Ensure secure bond of stopcock/bottom cap.
Drip Assembly and Drainage Bag Vent Integrity	Ensure that drip assembly and drainage bag vent can withstand appropriate fluid pressures.
Tensile Strength of Drainage Bag Inlet Port	Evaluate the tensile strength of the drainage bag inlet port to failure.
Drainage Bag Seal Weld	Ensure there are no leaks in the drainage bag.
Flow Initiation Pressure	Record pressure at which flow initiates, for each drainage bag.
Drip Assembly Vent Test (Exposure of Vent to Blood Solution)	Ensure that the drip assembly vent allows drainage of blood and provide CSF flow through system with minimal resistance.
Drip Assembly Vent Integrity	Test the drip assembly vent to withdraw fluid without compromising its mechanical integrity.
Leakage of UV-Cure Bonds	Record any leakage from the UV-cure bonds between the patient line and drip chamber subassembly.
Leakage of Drainage Bag	The drainage bag must withstand being inverted without leaking.
Drip Chamber Volume	Verify fluid weight in the drip chamber.
Attachment of I.V. Pole and Position of Adjustable Drip Chamber	Visually verify that clamping thumbscrews (and cord locks) have not slipped from initial positions (using visual marks to identify any slippage).
Leakage of UV Cure Bonds	The UV-cure bonds between the patient line and drip chamber subassembly should withstand air pressure without causing leaks.
Attachment of Junctions	Junctions must be able to withstand minimum of 5 pound load in the axial direction.
Bottom Cap to Stopcock Junction Torque	Test the torque of the stopcock/bottom cap bond.
Hydrophobic Microbial Barrier Vent on the Drainage Bag	The supplier for the material used as the drainage bag vents conducted microbial barrier testing to demonstrate a 99.9% Bacterial Filtration Efficiency (BFE).

SUMMARY OF CLINICAL INFORMATION

Although there was no formal clinical study conducted using the DUET™ EDMS for the expanded indication of temporary draining and monitoring of CSF flow from the lumbar subarachnoid space in patients undergoing open descending TAA/TAAA repair surgeries and patients post TAA/TAAA repair that become symptomatic with neurological deficit such as paraplegia, FDA believes that there is sufficient clinical data to support the expanded indication for this device. Given the worldwide clinical experience, the data and information provided support use of the device for the expanded indication as long as it is performed with a clear understanding of the risks associated with the device and clinical procedure. In describing the apparatus set-up, the CSF drains used in the clinical literature had similar characteristics (i.e., gravitational based pole-mounted apparatus with a

drainage bag) and operating principles as the subject device. The following is a summary of the clinical literature used to support the De Novo Indications for Use for the DUET™ EDMS in general:

1. Coselli et al. "Cerebrospinal Fluid Drainage Reduces Paraplegia after Thoracoabdominal Aortic Aneurysm Repair: Results of a Randomized Clinical Trial" (J. Vascular Surgery 2002; 35; p. 631-639). In this prospective, randomized study of 145 subjects, the effect of CSF drainage on the incidence of spinal cord injury (SCI) was evaluated in subjects undergoing surgical repair of Type I or II aortic aneurysms. In this study, additional concomitant methods were used for spinal cord protection; however, administration of CSF drainage was the only variable between the two treatment groups. During the procedure, CSF was drained freely with gravity if the CSF pressure exceeded 10 mmHg. The drain was removed two days post-operatively if the subject did not experience SCI, and was maintained beyond two days if SCI occurred. The authors reported a significant difference ($p = 0.03$) in the SCI rate, which was 2.7% in the CSF drainage group compared to 12.2% in the control group. This difference represents an 80% reduction in the occurrence of SCI and the authors concluded that CSF drainage is beneficial during the repair of Type I and II aortic aneurysms.

2. Estrera et al. "Descending Thoracic Aortic Aneurysm: Surgical Approach and Treatment using the Adjuncts Cerebrospinal Fluid Drainage and Distal Aortic Perfusion" (Ann. Thorac. Surg. 2001; 72; p. 481-486). A retrospective study was conducted to evaluate the concomitant use of Distal Aortic Perfusion (DAP) and CSF drainage in the prevention of neurological deficit during 148 non-emergent repairs of descending thoracic aortic aneurysms. The authors reported an overall neurological deficit rate of 2.7%.

3. Estrera et al. "Descending Thoracic Aortic Aneurysm Repair: 12-Year Experience using Distal Aortic Perfusion and Cerebrospinal Fluid Drainage" (Ann. Thorac. Surg. 2005; 80; p. 1290-1296). The authors presented the results of their 12-year experience comparing the rate of neurological deficit in 238 subjects who underwent aortic aneurysm repair in which DAP and CSF drainage were both administered (adjunct group) to 62 subjects with the use of CSF drainage alone (12 subjects), DAP alone (34 subjects), or neither adjunct was used (16 subjects). The results reported a neurological deficit rate of 1.3% for the adjunct group compared to 6.5% for the non-adjunct group ($p < 0.02$).

4. Safi et al. "Distal Aortic Perfusion and Cerebrospinal Fluid Drainage for Thoracoabdominal and Descending Thoracic Aortic Repair: Ten Years of Organ Protection" (Ann. Surg. 2003; 238; p. 372-380). The authors retrospectively examined the long term results of the combined administration of DAP, CSF drainage, and moderate hypothermia (adjunct group) compared to subjects in which no adjuncts were used for repairs of descending thoracic and TAAA. A total of 1004 subjects were evaluated with 741 subjects in the adjunct group (73.8%) and 263 subjects in the non-adjunct group (26.2%). Within the adjunct group, intraoperative CSF pressure was maintained at 10 mmHg and the mean arterial pressure between 90-100 mmHg. The CSF drain was employed for 3 days postoperatively and was continued for an additional 72 hours if neurological complications occurred. Results from this retrospective study demonstrated a neurological deficit rate of 2.4% for the adjunct group compared to a rate of 6.8% in the non-adjunct group ($p < 0.0009$). Use of the adjuncts prevented neurological

deficit in 1 in 20 cases for all patients, and 1 in 5 for Type II TAAA. The authors concluded that the study results suggest a multimodal approach including CSF drainage intra- and post-operatively can protect the spinal cord and reduce the risk of neurological complications.

5. Svensson et al. "Reduction of Neurologic Injury after High-Risk Thoracoabdominal Aortic Operation" (Ann. Thorac. Surg. 1998; 66; p. 132-138). The authors conducted a randomized, prospective study comparing the use of CSF drainage and Intrathecal papaverine (a vasodilator) in subjects undergoing high-risk TAAA repairs (treatment group) compared to no adjuncts (control group). Seventeen (17) subjects were enrolled in the treatment group and 16 subjects were enrolled in the control group. Within the treatment group, while the aorta was cross-clamped, CSF drained freely by gravity and once the clamp was removed, CSF drainage was discontinued unless CSF pressure exceeded 7 – 10 cm H_2O. Neurological deficit occurred in 2 subjects (11.8%) in the treatment group compared to 7 subjects (43.8%) in the control group ($p = 0.0392$). The authors concluded that for high-risk TAAA repairs, the combined CSF drainage and Intrathecal papaverine approach significantly reduced the incidence and severity of neurologic injury and that active cooling may further reduce the risk. The Institutional Review Board (IRB) terminated the study (for ethical reasons) with one-third of the target number of enrolled subjects, and an interim analysis of safety and effectiveness demonstrated a significant difference between the treatment and control groups. Consequently, early termination reduced the power of the study ($\alpha = 0.1$) and increased the possibility of statistical error. In conclusion, despite the reduced power of the study, CSF drainage and Intrathecal papaverine reduced the occurrence of SCI in high-risk patients.

   The provided clinical literature demonstrates reasonable assurance of safety and effectiveness in the use of a lumbar drainage system with the characteristics of the DUET™ EDMS for temporary CSF drainage to prevent neurological deficit and reduce spinal cord perfusion pressure and ischemia in patients undergoing open TAA/TAAA repair surgeries.

LABELING

The Instructions for Use for the DUET™ EDMS (for the De Novo indications) are consistent with the clinical data and cover all the hazards and other clinically relevant information that may impact use of the device. The labeling for the DUET™ EDMS is sufficient and satisfies the requirements of 21 CFR § 801.109 Prescription Devices. The labeling for the DUET™ EDMS includes:

1. The indicated use population and environment.
2. Contraindications with respect to patients who should not receive a lumbar drain.
3. Requirement with respect to 24-hour-a-day availability of trained personnel to supervise monitoring and drainage.
4. Detailed instructions on proper device set-up, positioning and monitoring.
5. Appropriate warnings and precautions to inform the user of the potential serious hazards and special care associated with the use of the device.
6. A detailed summary of the device- and procedure-related complications or adverse events.
7. Instructions which state that the device is not to be reused, reprocessed, or resterilized when open but unused.
8. Cleaning instructions for the injection sites.

9. Recommendation for use with the Clear-Site™ Laser Level (cleared under K984053) that is provided separately.

RISKS TO HEALTH

Table 4 below identifies the risks to health that may be associated with use of a cerebrospinal fluid shunt system and the measures necessary to mitigate these risks.

Table 4: Identified Risks to Health and Mitigation Measures

Identified Risk	Mitigation Measure
Pyrogenicity/adverse tissue reaction	Biocompatibility evaluation Pyrogenicity testing Labeling Shelf life testing Sterilization validation
Infection (including meningitis)	Labeling Sterilization validation Package integrity testing
Cerebrospinal fluid (CSF) leakage	Labeling Non-clinical performance testing
Over- & under-drainage • Spinal headache with and without CSF leakage • Intracranial hemorrhage • Hematoma (e.g., spinal, subdural) • Paraplegia • Foreign body obstruction	Labeling Non-clinical performance testing
Procedural/use errors	Labeling

SPECIAL CONTROLS:

In combination with the general controls of the FD&C Act, the cerebrospinal fluid shunt system is subject to the following special controls:

1. The device description must include a detailed summary of the device technical parameters, including design configuration, dimensions, engineering drawings, and a list of all components with identification of their materials of construction.

2. The patient-contacting components of the device must be demonstrated to be biocompatible.

3. Non-clinical performance testing must demonstrate that the device performs as intended under anticipated conditions of use. The following performance characteristics must be tested:
   a. Simulated use testing must be conducted to characterize fluid flow and resistance to leakage.
   b. Mechanical integrity testing of all connections must be conducted.

4. Performance data must support the shelf life of the device by demonstrating continued sterility, package integrity, and device functionality over the specified shelf life.

5. Performance data must demonstrate the sterility and pyrogenicity of patient-contacting components of the device.

6. The labeling must include:
   a. Contraindications with respect to patients who should not receive a lumbar drain;
   b. A warning that the device should have 24-hour-a-day availability of trained personnel to supervise monitoring and drainage;
   c. Instructions on proper device set-up, positioning and monitoring;
   d. Warnings and precautions to inform the user of serious hazards and special care associated with the use of the device;
   e. A statement that the device is not to be reused, reprocessed, or resterilized when open but unused; and
   f. Cleaning instructions for the injection sites.

BENEFIT/RISK DETERMINATION

The risks of the device are based on data as evidenced in the clinical literature. The risks associated with lumbar CSF drainage using the subject device include excessive drainage of CSF that can lead to cranial subdural hematoma, infection/meningitis, CSF leakage with or without spinal headache, and drainage fluid that is not clear or not flowing indicating problems with coagulopathy or a malfunction of the drain (e.g., catheter fracture or occlusion). In the clinical literature titled, "Complications of Spinal Fluid Drainage in Thoracoabdominal Aortic Aneurysm Repair: A Report of 486 Patients Treated from 1987 to 2008" (Wynn et al. Journal of Vascular Surgery 2009. 49; p. 29-34), the results revealed a 5% rate of bloody spinal fluid and 2.9% rate of intracranial blood without neurological deficit. In addition, it was reported that neurological deficits and mortality due to CSF drainage occurred in 1% and 0.6% of patients, respectively.

The probable benefits of the device are also based on data collected in the clinical literature as described above. The benefit of the device includes the reduction of paraplegia after open thoracic aortic aneurysm (TAA) or open thoraco-abdominal aortic aneurysm (TAAA) repair surgery with CSF drainage. In the published clinical literature from Coselli et al., a prospective, randomized study of 145 subjects determined that the risk of spinal cord injury (SCI) was 12.2% in the control group compared to 2.7% in the lumbar CSF drainage group for the surgical repair of open Type I/II aortic aneurysms. In patients who achieve a probable benefit from using this device, the effect would be the prevention of SCI.

Additional factors to be considered in determining probable risks and benefits for the DUET™ EDMS include: The effectiveness data were primarily based on one randomized prospective study of 145 subjects in the Coselli et al. publication. There were several other retrospective studies published in the clinical literature including a retrospective study from Estrera et al. who used distal aortic perfusion (DAP) concurrent with CSF drainage in the prevention of neurological deficit during 148 non-emergent repairs of descending thoracic aortic aneurysms.

The results showed that the rate of neurological deficit in 238 subjects was 1.3% for the adjunct group in which DAP was used concurrently with CSF drainage compared to 6.5% for the control group (i.e., only CSF drainage, only DAP, and neither CSF drainage or DAP). In a separate retrospective study from Safi et al., the long term results of the combined administration of DAP, CSF drainage, and moderate hypothermia (adjunct group) were compared to subjects in which no adjuncts were used for repairs of descending thoracic and thoracoabdominal aortic aneurysms. A total of 1004 subjects were evaluated, and the results showed a neurological deficit rate of 2.4% for the adjunct group compared to a rate of 6.8% in the non-adjunct group. Svensson et al. conducted a randomized prospective study comparing the use of CSF drainage and intrathecal papaverine (a vasodilator) in subjects undergoing high-risk TAAA repairs (17 subjects) in comparison with no adjuncts (16 subjects). The results demonstrated that neurological deficit occurred in 11.8% of subjects in the treatment group compared to 43.8% in the control group. Based on the data in the clinical literature, the benefit of using the subject device is most effective in patients undergoing open TAA and open TAAA repairs. Because SCIs can be difficult to treat, are chronic conditions, and there are few good interventions to help these patients, the use of CSF drainage has the potential to lower the risk of SCI and improve the quality of life in patients undergoing open TAA and open TAAA repair surgeries. Currently, CSF drainage is the most common treatment for open TAA and open TAAA repair surgeries and involves the off-label use of lumbar drain systems. Intrathecal agents may be an alternative to CSF drainage.

In conclusion, given the available information, the data support that the probable benefits outweigh the probable risks of temporary draining and monitoring CSF flow from the lumbar subarachnoid space in patients undergoing open descending TAA or open descending TAAA repair surgery or in post TAA/TAAA patients who are symptomatic for neurological deficit such as paraplegia. The Medtronic Neurosurgery DUET™ EDMS, as a lumbar drainage system, provides benefits and the risks can be mitigated by the use of general controls and the identified special controls.

CONCLUSION

The De Novo request for the Medtronic Neurosurgery DUET™ External Drainage and Monitoring System (EDMS) is granted and the device is classified under the following:

Product Code: PCB
Device Type: Cerebrospinal fluid shunt system
Class: II
Regulation: 21 CFR 882.5560