Policy Number	**ADM1001.032**
Policy Effective Date	**05/15/2025**

Experimental, Investigational and/or Unproven Procedures/Services

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Related Policies (if applicable)
None

Disclaimer

Medical policies are a set of written guidelines that support current standards of practice. They are based on current peer-reviewed scientific literature. A requested therapy must be proven effective for the relevant diagnosis or procedure. For drug therapy, the proposed dose, frequency and duration of therapy must be consistent with recommendations in at least one authoritative source. This medical policy is supported by FDA-approved labeling and/or nationally recognized authoritative references to major drug compendia, peer reviewed scientific literature and acceptable standards of medical practice. These references include, but are not limited to: MCG care guidelines, DrugDex (IIa level of evidence or higher), NCCN Guidelines (IIb level of evidence or higher), NCCN Compendia (IIb level of evidence or higher), professional society guidelines, and CMS coverage policy.

Carefully check state regulations and/or the member contract.

Each benefit plan, summary plan description or contract defines which services are covered, which services are excluded, and which services are subject to dollar caps or other limitations, conditions or exclusions. Members and their providers have the responsibility for consulting the member's benefit plan, summary plan description or contract to determine if there are any exclusions or other benefit limitations applicable to this service or supply. **If there is a discrepancy between a Medical Policy and a member's benefit plan, summary plan description or contract, the benefit plan, summary plan description or contract will govern.**

Coverage

The following list of procedures/services **are considered experimental, investigational and/or unproven** as there is insufficient evidence to support long-term safety and/or efficacy.

Service/Procedure	Code(s)
Eye movement analysis without spatial calibration for concussion (EyeBOX®)	0615T
Tibial or peroneal vein endovascular arterialization (LimFlow Stent Graft System)	0620T

Excimer laser trabeculostomy for glaucoma (ExTra ELT)	0621T; 0622T
AI-Enabled Quantitative Coronary Plaque Analysis (e.g., Cleerly Coronary®, Heartflow®)	0623T; 0624T; 0625T; 0626T
Visible light hyperspectral imaging (HyperView™)	0631T
Flow sense™	0639T
Noncontact near-infrared spectroscopy studies of flap or wound (e.g., Snapshot NIR)	0640T; 0859T
Transcatheter left ventricular restoration device implantation	0643T
Transcatheter implantation of coronary sinus reduction device	0645T
Topical Gastrointestinal Hemostatic Agent (e.g., Hemospray® Endoscopic Hemostat Device)	C1052
Intravascular lithotripsy (Shockwave Medical Intravascular Lithotripsy [IVL] System)	92972, C1761, C9764; C9765; C9766; C9767; C9772, C9773, C9774, C9775
Transoral esophageal mucosal integrity testing by electrical impedance (e.g., MiVu)	C9777
Assistive algorithmic electrocardiogram risk-based assessment for cardiac dysfunction	0764T, 0765T, C9786
Bioprosthetic valve for chronic venous insufficiency (Venous Valve)	0744T
Virtual reality technology	0770T, 0771T, 0772T, 0773T, 0774T, 0791T, E1905
Surface mechanomyography	0778T
Real-time pressure-sensing epidural guidance system	0777T
Darvadstrocel (Alofisel)	0748T
Pulmonary tissue ventilation analysis (e.g., XV Lung Ventilation Analysis Software System)	0807T, 0808T
Intermittent abdominal pressure ventilation devices	A4468
Cardiac acoustic waveform recording with automated coronary artery disease risk score	0716T
Neuromodulation stimulator system (e.g., Portable Neuromodulation Stimulator™)	A4593, A4594
Battery powered walker (e.g., Sully Walker)	E0152
Extremity rehabilitation system providing active assistance (e.g., IpsiHand™ Upper Extremity Rehabilitation System, Motus Hand, Motus Foot)	E0738, E0739

Policy Guidelines

None.

Description

Refer to Rationale for descriptions of services/procedures.

Rationale

This policy was developed based on literature review using the PubMed database.

Eye Movement Analysis (EyeBOX)
Effective Date: 05/15/2021
Updates: 05/15/2025
Review: 01/15/2023

Eye movement analysis without spatial calibration for concussion (EyeBOX)	0615T

The EyeBOX is intended to measure and analyze eye movement as an aid in the diagnosis of concussion within one week of head injury in patients 5 through 67 years of age in conjunction with a standard neurological assessment of concussion. Using a proprietary processing algorithm and machine learning technology that measures and analyses eye movement while the patient watches a 220 second video, the device then calculates a score on a 0-20 scale based on these measurements and displays an EyeBOX classification based upon whether the scale value is above 10 or not. Scale values of 10 or more yield a positive classification that may correspond to eye movement that may be present in both patients with or without a concussion, while scale values under 10 yield a negative classification that may correspond with eye movement that is consistent with a lack of concussion.

In a cross-sectional case-control study, Bin Zahid et al. (2020) evaluated an automated eye-tracking algorithm as a biomarker for concussion. (1) Concussed children (n=56; mean age of 13 years) were compared with 83 uninjured controls at a mean of 22-weeks post-injury. Metrics comparing velocity and conjugacy of eye movements over time were obtained and were compared with the correlation between Acute Concussion Evaluation (ACE) scores, convergence, and accommodation dysfunction. The subjects' eye movement were recorded with an automated eye tracker while they watched a 22-second cartoon film clip played continuously while moving within an aperture. Twelve eye-tracking metrics were significantly different between concussed and non-concussed children. A model to classify concussion as diagnosed by its symptoms assessed using the ACE achieved an area under the curve (AUC) = 0.854 (71.9% sensitivity, 84.4% specificity, a cross-validated AUC = 0.789). An eye-tracking model built to identify near point of convergence (NPC) disability achieved 95.8% specificity and 57.1% sensitivity for an AUC = 0.810. Reduced binocular amplitude of accommodation had a Spearman correlation of 0.752 (P value <0.001) with NPC. Researchers concluded that eye tracking correlated with concussion symptoms and detected convergence and accommodative abnormalities associated with concussion in the pediatric population.

Samadani et al. (2015) conducted a single-center prospective study (n=322) to determine the sensitivity and specificity of a novel eye tracking metric as a biomarker for concussion. (2) Brain injured (n=34) and control subjects (n=34) underwent both eye tracking performed while watching television or a video moving inside an aperture with a set trajectory for 220 seconds, and Sport Concussion Assessment Tool 3. The results of eye tracking biomarker-based classifier models were then validated against a dataset of individuals not used in building a model (n=254; adults with concussion [n=7] and uninjured adults [n=247]). Significant group differences between brain injured and concussed subjects versus negative controls were found for 28 eye tracking metrics that were not influenced by age or gender. These were used to develop the three classifier functions. In a sample of 21 concussion cases versus age and gender balanced uninjured controls, the 'best subset' model selected four metrics and the resulting receiver operating characteristic of the classifier had an area under the curve (AUC) of 0.878, and a cross-validated AUC of 0.852. The LASSO model selected two metrics and resulted in an AUC of 0.880 and a cross-validated AUC of 0.826. In an external dataset of 254 subjects (247 controls and 7 concussions), 'best subset' had a misclassification rate of 14.2%, LASSO had a misclassification rate of 13.8% and random forest had a misclassification rate of 13.0%. Researchers concluded that although current results are promising, additional data on potential confounders of eye tracking still need to be investigated. These include alcohol and other intoxicants, fatigue and prior history of trauma and neurologic or ophthalmic disorders among others.

Samadani et al. (2015) developed an algorithm for eye tracking in which the Cartesian coordinates of the right and left pupils are tracked over 200 sec and compared to each other as a subject watches a short film clip moving inside an aperture on a computer screen. (3) Researchers prospectively eye tracked 64 normal healthy noninjured control subjects and compared findings to 75 trauma subjects with either a positive head computed tomography (CT) scan (*n*=13), negative head CT (*n*=39), or nonhead injury (*n*=23) to determine whether eye tracking would reveal the disconjugate gaze associated with both structural brain injury and concussion. Tracking metrics were then correlated to the clinical concussion measure Sport Concussion Assessment Tool 3 (SCAT3) in trauma patients. Five out of five measures of horizontal disconjugacy were increased in positive and negative head CT patients relative to noninjured control subjects. Only one of five vertical disconjugacy measures was significantly increased in brain-injured patients relative to controls. Linear regression analysis of all 75 trauma patients demonstrated that three metrics for horizontal disconjugacy negatively correlated with SCAT3 symptom severity score and positively correlated with total Standardized Assessment of Concussion score. Abnormal eye-tracking metrics improved over time toward baseline in brain-injured subjects observed in follow-up. There were a number of limitations to this data, including: 1) in the control subject population, medical and ophthalmic history was self-reported, 2) many subjects were hospital employees, research volunteers, colleagues, or friends of the investigative team and may not have been forthcoming about their past medical history, medications, and drugs used in the day preceding eye-tracking testing, 3) the long-term impact of medications and other agents consumed greater than 1 day before is unknown, 4) not all patients in all comparison groups were on the same concomitantly administered

mediations, 5) congenital confounders and other conditions leading to acquired disconjugacy, and 6) neither formal optometric nor ophthalmic testing was performed in the trauma settings.

Howell et al. (2018) evaluated eye-tracking measurements among adolescents within 10 days of concussion and healthy control participants. (4) Patients who reported to 2 tertiary care sport concussion clinics within 10 days of concussion completed an objective eye tracking assessment. Seventy-nine participants completed the study, 44 with concussion (mean age = 14.1 ± 2.2 years, 39% female) and 35 controls (mean age = 14.3 ± 2.4 years, 57% female). Right eye skew along the bottom of the screen was significantly higher for the concussion group compared to controls (median = 0.022 [interquartile range = -0.263, 0.482] vs 0.377 [interquartile range = -0.574, -0.031]; P = .002), but not the left eye. Among the variables investigated, right eye skew was altered for adolescents with a concussion. Limitations of the study include: 1) participant sample was composed of patients who reported for care after a concussion to 1 of 2 specialized sport concussion clinics associated with a regional tertiary care hospital, therefore findings from this cohort of individuals may not be generalizable to other populations of individuals with concussion, and 2) the inclusion of some individuals with attention-deficit disorders (ADD) or attention-deficit hyperactivity disorder (ADHD) may have influenced the results. In conclusion, the normalized amount of asymmetry around the mean of the eye trajectory while watching a video was greater among adolescents who were tested within 10 days of a concussion than controls. This represents a potentially useful paradigm to allow clinicians across a variety of practice settings to identify vision-related problems after a concussion. However, further work is needed to validate and generalize these results to other populations.

In a repeated-measures study, Howell et al. (2018) sought to determine the test-retest correlation of an objective eye-tracking device among uninjured youth athletes. (5) Healthy youth athletes (mean age = 14.6 ± 2.2 years; 39% women) completed a brief, automated, and objective eye-tracking assessment at two different testing sessions. During the assessment, participants watched a 220-second video clip while it moved around a computer monitor in a clockwise direction as an eye tracker recorded eye movements. We obtained 13 eye movement outcome variables and assessed correlations between the assessments made at the 2 time points using Spearman's Rho (rs). Thirty-one participants completed the eye-tracking evaluation at 2 time points [median = 7 (interquartile range = 6-9) days between tests]. No significant differences in outcomes were found between the 2 testing times. Several eye movement variables demonstrated moderate to moderately high test-retest reliability. Combined eye conjugacy metric (BOX score, rs = 0.529, P = 0.008), the variance of the ratio for both eye movements in the horizontal (rs = 0.497, P = 0.013) and vertical (rs = 0.446; P = 0.029) movement planes along the top/bottom of the computer screen, and the variance of the left and right eye movement along the bottom segment of the computer screen (rs = 0.565; P = 0.004) each demonstrated moderate between-test correlations. Researchers concluded that Automated and quantitative eye movement and conjugacy metrics provide relatively stable measurements among a group of healthy youth athletes. Thus, their inclusion as a visual tracking metric may be complementary to other visual examination techniques when

monitoring concussion recovery across time. Future studies with larger samples should be conducted to further establish the psychometric properties of eye-tracking measurements.

Jain et al. (2022) explored the utility of a 220-second eye tracking assessment in distinguishing eye position, saccadic movement, and pupillary dynamics among uninjured adolescents, those with acute post-concussion symptoms (≤28 days since concussion), or those with persistent post-concussion symptoms (>28 days since concussion). (6) Two hundred fifty-six eye tracking metrics across a prospective observational cohort of 180 uninjured adolescents recruited from a private suburban high school and 224 concussed adolescents, with acute or persistent symptoms, recruited from a tertiary care subspecialty concussion care program, 13 to 17 years old, from August 2017 to June 2021 were compared. Kruskal-Wallis tests were used, and Bonferroni corrections were applied to account for multiple comparisons and constructed receiver operating characteristic curves. Principal components analysis and regression models were applied to determine whether eye tracking metrics can augment clinical and demographic information in differentiating uninjured controls from concussed adolescents. Two metrics of eye position were worse in those with concussion than uninjured adolescents, and only one metric was significantly different between acute cases and persistent cases. Concussed adolescents had larger left and right mean, median, minimum, and maximum pupil size than uninjured controls. Concussed adolescents had greater differences in mean, median, and variance of left and right pupil size. Twelve metrics distinguished female concussed participants from uninjured; only four were associated with concussion status in males. A logistic regression model including clinical and demographics data and transformed eye tracking metrics performed better in predicting concussion status than clinical and demographics data alone. Researchers concluded that eye tracking is a promising objective method that may potentially supplement current clinical assessments as a dynamic objective measure of vision and autonomic dysfunction. Future work should involve modifying and consolidating these metrics in a generalizable way and combining them with existing clinical measures to monitor recovery in a heterogeneous adolescent concussion population.

Samadani et al. (2022) conducted an eye tracking study in order to obtain FDA Marketing Authorization for aid in the diagnosis of concussion. (7) Potentially concussed subjects recruited in emergency department and concussion clinic settings prospectively underwent eye tracking and a subset of the Sport Concussion Assessment Tool 3 (SCAT3) at 6 sites. The results of an eye tracking-based classifier model were then validated against a pre-specified algorithm with a cutoff for concussed vs. non-concussed. The sensitivity and specificity of eye tracking were calculated after plotting of the receiver operating characteristic curve and calculation of the AUC (area under curve). When concussion is defined by SCAT3 subsets, the sensitivity and specificity of an eye tracking algorithm was 80.4 and 66.1%, The AUC was 0.718. The misclassification rate (*n* = 282) was 31.6%. It should be noted that the reported sensitivity and specificity indicate consistency with an arbitrarily defined clinical references standard of symptoms severity plus cognitive assessment. Because there is currently no gold-standard clinical definition of concussion and no known cut-off value that is widely validated, researchers had to arbitrarily select a cutoff. In addition, the SCAT tests are designed for use in athletes rather than the general population, who have more diverse comorbidities.

In a 2023 Evidence Analysis, ECRI classified the confidence in evidence on EyeBOX's diagnostic accuracy for concussion in conjunction with standard neurological assessment and its clinical utility for improving patient outcomes to be "very low" with "too few data on outcomes of interest." Whether adding EyeBOX to standard diagnostic processes for aiding in the diagnosis of concussion improves diagnostic accuracy cannot be determined from available evidence. No published studies provide evidence to assess EyeBOX's effect on patient outcomes or patient management decisions. (8)

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LimFlow Stent Graft System

Effective Date: 01/01/2021
Updates: 05/15/2025
Review: 01/15/2023

Tibial or peroneal vein endovascular arterialization (LimFlow Stent Graft System)	0620T

LimFlow is a minimally invasive technology designed to divert blood around diseased arteries in the leg and into the tibial veins that feed the foot. (1) This technique would bring blood and oxygen to the starved tissues in the foot, relieving pain and promoting healing of chronic wounds.

Schmidt et al. conducted a retrospective study of 32 patients suffering from no-option chronic limb-threatening ischemia (CLTI) treated with a dedicated system for percutaneous deep venous arterialization (pDVA) using the LimFlow device between July 2014 and June 2018. (2) Of all patients, 21 (66%) had diabetes, 8 (25%) were on immunosuppression, 4 (16%) had dialysis-dependent renal failure, 9 (28%) had Rutherford category 6 ischemia, and 25 (78%) were deemed at high risk of amputation. The primary outcome was amputation-free survival (AFS) at 6 months. Secondary outcomes were wound healing, limb salvage, and survival at 6, 12, and 24 months. Technical success was achieved in 31 patients (96.9%). The median follow-up was 34 months (range 16-63). At 6, 12, and 24 months, estimates were 83.9%, 71.0%, and 67.2% for AFS, 86.8%, 79.8% and 79.8% for limb salvage, and 36.6%, 68.2%, and 72.7% for complete wound healing, respectively. Median time to complete wound healing was 4.9 months (range 0.5-15). The DVA circuit occluded during follow-up in 21 patients; the median time to occlusion was 2.6 months. Reintervention for occlusion was performed in 17 patients: 16 because of unhealed wounds and 1 for a newly developed ulcer. The authors concluded percutaneous deep venous arterialization could be a recommended treatment to prevent amputation and heal wounds.

Clair et al. (2021) reported the 6- and 12-month outcomes of the PROMISE I early feasibility study after treatment of no-option CLTI with pDVA using the LimFlow System. (3) Thirty-two patients with no-option CLTI, previously offered major amputation, were enrolled in this single-arm early feasibility study of the LimFlow pDVA System. No-option CLTI was defined as being ineligible for surgical or endovascular arterial revascularization. Patients were assessed for clinical status, pain, wound healing, and duplex ultrasound at 30 days, 6 months, and 12 months post-treatment. Primary endpoint analysis was AFS at 30 days and 6 and 12 months. AFS was defined as freedom from above-ankle amputation of the index limb and freedom from all-cause mortality. Secondary endpoints evaluated included technical success of the procedure, and wound healing at 6 and 12 months. Of 32 enrolled patients, 31 (97%) were successfully treated with the LimFlow System at the time of the procedure, and two (6.3%) were lost to follow-up. The 30-day, 6-month, and 12-month AFS rates were 91%, 74%, and 70% respectively. The wound healing status of fully healed or healing was 67% at 6 months, and 75% at 12 months. Reintervention was performed in 16 patients (52%) with 14 (88%) of the maintenance reinterventions occurring within the first 3 months. The majority of reinterventions (n = 12; 75%), involved the arterial inflow tract proximal to the stented LimFlow circuit, and no in-stent stenoses were determined to have been the cause of reintervention. The LimFlow pDVA System was utilized in treating patients with no-option CLTI. These results suggest early safety and provide an initial assessment of the efficacy of the LimFlow pDVA System that supports the expansion of carefully executed studies to determine whether this is a viable option that can be used in this critically disadvantaged and growing patient population.

Shishehbor et al. (2023) conducted a prospective, single-group, multicenter study (PROMISE II) to evaluate the effect of transcatheter arterialization of the deep veins in patients with nonhealing ulcers and no surgical or endovascular revascularization treatment options. (4) The composite primary end point was amputation-free survival (defined as freedom from above-ankle amputation or death from any cause) at 6 months, as compared with a performance goal

of 54%. Secondary end points included limb salvage, wound healing, and technical success of the procedure. One hundred and five patients who had chronic limb-threatening ischemia and were of a median age of 70 years (interquartile range, 38 to 89) were enrolled. Of the patients enrolled, 33 (31.4%) were women and 45 (42.8%) were Black, Hispanic, or Latino. Transcatheter arterialization of the deep veins was performed successfully in 104 patients (99.0%). At 6 months, 66.1% of the patients had amputation-free survival. According to Bayesian analysis, the posterior probability that amputation-free survival at 6 months exceeded a performance goal of 54% was 0.993, which exceeded the prespecified threshold of 0.977. Limb salvage (avoidance of above-ankle amputation) was attained in 67 patients (76.0% by Kaplan-Meier analysis). Wounds were completely healed in 16 of 63 patients (25%) and were in the process of healing in 32 of 63 patients (51%). No unanticipated device-related adverse events were reported. Researchers concluded that transcatheter arterialization of the deep veins was safe and could be performed successfully in patients with chronic limb-threatening ischemia and no conventional surgical or endovascular revascularization treatment options.

In a commentary on the PROMISE II study, Cormican et al. (2023) acknowledged the positive outcomes from the trial but also pointed out that the trial left much for consideration when assessing the study results in total, including that it was not a randomized trial and the follow-up was only 12 months postintervention, rather than the planned 3 years. (5) Additionally, within the study population who underwent transcatheter arterialization of the deep veins (TADV), 19 out of 105 (18.1%) patients were dialysis-dependent (DD); the DD cohort had much worse outcomes than the study group who did not require dialysis. Investigation into potential mechanisms for the worse outcomes was not offered, and the specific cause/mechanism of death was not outlined within the PROMISE II manuscript. Because the risk factors associated with end-stage renal disease (ESRD) and CLTI are so closely shared, it will be important as the study and implementation of forward TAV progress to see if the abysmal outcomes in DD patients were a true signal or only noise. More importantly, 2 essential elements of the CLTI symptom profile were not directly addressed in the PROMISE II manuscript -- rest pain and functional status. Although amputation avoidance and wound healing are of paramount importance, those patients who have CLTI without a functional limb may, in fact, be better served with amputation in some cases. Furthermore, although the technology, technique, experience, and equipment used for TADV will hopefully advance over time to be more friendly to both proceduralists and patients, it must be noted that the vast majority of patients (almost 75%) required some re-intervention on the TADV circuit to ensure primary patency. Moreover, 93.3% had at least 1 of the trial's pre-defined AEs during the study period; although many of the adverse events may have been comparatively minor to limb amputation or other significant events, it should be underscored that almost every subject had an adverse event. Finally, the study protocol was designed and sponsored by LimFlow “with input from” the principal investigators; although this conduct in important, well-designed, ethical trials is not unheard of, it is important to consider this fact when evaluating some of the afore-mentioned limitations. Authors noted that the PROMISE II Trial provided some early promise as an intervention that may benefit patients with CLTI who would otherwise not have another management option. They stated that further investigations, especially those comparing TA intervention to a control group as well as studies to define the outcomes in particular

subgroups (i.e., patients who are DD with CLTI), are needed before moving this experimental therapy to all patients with CLTI.

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ExTra Excimer Laser Trabeculostomy (ELT)

Effective Date: 01/01/2021
Updates: 05/15/2025
Review: 01/15/2023

Excimer laser trabeculostomy for glaucoma (ExTra ELT)	0621T; 0622T

Excimer laser trabeculostomy (ELT) is a microinvasive glaucoma surgery (MIGS) that creates multiple laser channels through the trabecular meshwork using a cold laser system, which minimizes tissue fibrosis and aids in bypassing the main area of resistance to aqueous outflow.

Durr et al. published a review of studies (1 randomized controlled trial [RCT], 4 prospective case series and 5 retrospective studies) on the use of excimer laser trabeculostomy for glaucoma. (1) The authors found that non-head-to-head prospective randomized study comparing standalone ELT to trabecular bypass MIGS or trabeculotomies had been conducted. The best evidence was from an RCT comparing ELT to 180-degree selective laser trabeculoplasty (SLT). ELT appeared to outperform SLT although it was not statistically significant likely due to an underpowered study. There is a question as to if SLT is the best comparator, as SLT is an incision-less procedure. The authors concluded their review by stating that current available evidence shows an intra-ocular pressure lowering effect from ELT alone or in combination with cataract surgery with encouraging results across different studies and patient populations. There was less scarring using ELT than from traditional thermal lasers, as well as repeatability in different quadrants, ease of use and lower hyphema risks compared to ablative procedures. The procedure also

appears to have a favorable safety profile with few intraoperative or postoperative risks. More studies are needed to better characterize ELT further substantiate promising results.

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Artificial Intelligence (AI)-Enabled Quantitative Coronary Plaque Analysis (e.g., Cleerly Coronary®, Heartflow®)

Effective Date: 01/01/2021
Updates: 07/01/2023
Review: 01/15/2023, 05/15/2025

AI-enabled quantitative coronary plaque analysis	0623T; 0624T; 0625T; 0626T

The Cleerly Coronary® Data Visualization Platform is a web-based service that provides analysis of data obtained with a coronary computed tomography (CT) angiography. It assesses for coronary heart disease by quantifying and characterizing arterial plaque buildup. The software uses machine learning algorithms to help clinicians segment CT angiography (CTA) images and measures morphologic parameters, including vessel and plaque dimensions, stenosis severity and plaque calcification. The results are summarized on an interactive three-dimensional rendering of the patient's coronary vasculature, which can be used to assess individual lesion risk and overall disease burden. (2)

In a multi-site study of 232 patients undergoing coronary computed tomography angiography (CCTA), Choi et al. analyzed CCTA results for percent of maximal diameter stenosis, plaque volume and composition, presence of high-risk plaque and Coronary Artery Disease Reporting & Data System (CAD-RADS) category. (3) Artificial intelligence (AI) performance was excellent for accuracy, sensitivity, specificity, positive predictive value, and negative predictive value as follows: >70% stenosis: 99.7%, 90.9%, 99.8%, 93.3%, 99.9%, respectively; >50% stenosis: 94.8%, 80.0%, 97.0, 80.0%, 97.0%, respectively. Bland-Altman plots depict agreement between expert reader and AI determined maximal diameter stenosis for per-vessel (mean difference −0.8%; 95% CI 13.8% to −15.3%) and per-patient (mean difference −2.3%; 95% CI 15.8% to −20.4%). Level 3 readers (L3) and AI agreed within one CAD-RADS category in 228/232 (98.3%) exams per-patient and 923/924 (99.9%) vessels on a per-vessel basis.

Lipkin et al. reported on a retrospective post hoc analysis of the derivation cohort of the prospective Computed Tomographic Evaluation of Atherosclerotic Determinants of Myocardial Ischemia (CREDENCE) trial. (4) The study included 301 patients (88 women and 213 men; mean age, 64.4 ± 10.2 [standard deviation (SD)] years) recruited from May 2014 to May 2017 with stable symptoms of myocardial ischemia referred for nonemergent invasive angiography. Patients underwent coronary CTA and myocardial perfusion imaging (MPI) before angiography with quantitative coronary angiography (QCA) measurements and fractional flow reserve (FFR).

CTA examinations were analyzed using an FDA-cleared cloud-based software platform that performs artificial intelligence quantitative CT (AI-QCT) for stenosis determination. Diagnostic performance was evaluated. Diagnostic algorithms were compared. Among 102 patients with no ischemia on MPI, AI-QCT identified obstructive (≥ 50%) stenosis in 54% of patients, including severe (≥ 70%) stenosis in 20%. Among 199 patients with ischemia on MPI, AI-QCT identified nonobstructive (1–49%) stenosis in 23%. AI-QCT had significantly higher area under the curve (AUC) (all $p < .001$) than MPI for predicting ≥ 50% stenosis by QCA (0.88 vs. 0.66), ≥ 70% stenosis by QCA (0.92 vs. 0.81), and FFR < 0.80 (0.90 vs. 0.71). An AI-QCT result of ≥ 50% stenosis and ischemia on stress MPI had sensitivity of 95% versus 74% and specificity of 63% versus 43% for detecting ≥ 50% stenosis by QCA measurement. Compared with performing MPI in all patients and those showing ischemia undergoing invasive angiography, a scenario of performing coronary CTA with AI-QCT in all patients and those showing ≥ 70% stenosis undergoing invasive angiography would reduce invasive angiography utilization by 39%; a scenario of performing MPI in all patients and those showing ischemia undergoing coronary CTA with AI-QCT and those with ≥ 70% stenosis on AI QCT undergoing invasive angiography would reduce invasive angiography utilization by 49%.

A retrospective analysis of data from 303 patients including coronary CTA, FFA and QCA from the derivation arm of the CREDENCE trial was evaluated by Griffin et al. (5) Disease prevalence was high, with 32.0%, 35.0%, 21.0%, and 13.0% demonstrating ≥50% stenosis in 0, 1, 2, and 3 coronary vessel territories, respectively. Average AI-QCT [artificial intelligence-enabled quantitative computed tomography] analysis time was 10.3 ± 2.7 minutes. AI-QCT evaluation demonstrated per-patient sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of 94%, 68%, 81%, 90%, and 84%, respectively, for ≥50% stenosis, and of 94%, 82%, 69%, 97%, and 86%, respectively, for detection of ≥70% stenosis. There was high correlation between stenosis detected on AI-QCT evaluation vs. QCA on a per-vessel and per patient basis (intraclass correlation coefficient = 0.73 and 0.73, respectively; $P < 0.001$ for both). False-positive AI-QCT findings were noted in 62 of 848 (7.3%) vessels (stenosis of ≥70% by AI-QCT and QCA of <70%); however, 41 (66.1%) of these had an FFR of <0.8.

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Visible light hyperspectral imaging (HyperView™)
Effective Date: 01/01/2021
Updates: 05/15/2025
Review: 01/15/2023

Visible light hyperspectral imaging (HyperView™)	0631T

HyperView™ is a handheld battery-operated portable device that utilizes a proprietary form of hyperspectral imaging to assess oximetry in superficial tissue. According to the product brochure, it "uses visible light and an internal spectrometer to differentiate light absorption between oxygenated hemoglobin and deoxygenated hemoglobin. Results are presented as color-coded images containing quantitative data which depict levels of oxyhemoglobin and deoxyhemoglobin, as well as oxygen saturation values. Built-in software tools allow the clinician to analyze various areas within the image corresponding to locations on the skin surface. This allows the clinician to determine areas of ischemic tissue and visualize arterial and venous sufficiency in localized tissue, for example the boundary around a diabetic foot ulcer." (1)

The U.S. Food and Drug Administration (FDA) granted approval of the HyperView™ device based on a predicate device developed by the same company. (2) It is indicated for use by physicians and healthcare professionals as a noninvasive tissue oxygenation measurement system that reports an approximate value of oxygen saturation, oxyhemoglobin level and deoxyhemoglobin levels in superficial tissue for patients with potential circulatory compromise.

In 2009, Nouvong et al. published results from a prospective single-arm blinded study of 66 patients with type 1 and type 2 diabetes. (3) Transcutaneous oxygen tension was measured at the ankles. Superficial tissue oxyhemoglobin (oxy) and deoxyhemoglobin (deoxy) were measured with hyperspectral imaging from intact tissue bordering the ulcer. A healing index derived from oxy and deoxy values was used to assess the potential for healing. Fifty-four patients with 73 ulcers completed the study; at 24 weeks, 54 ulcers healed while 19 ulcers did not heal. When using the healing index to predict healing, the sensitivity was 80% (43 of 54), the specificity was 74% (14 of 19), and the positive predictive value was 90% (43 of 48). The sensitivity, specificity, and positive predictive values increased to 86, 88, and 96%, respectively, when removing three false-positive osteomyelitis cases and four false-negative cases due to measurements on a callus. The results indicate that cutaneous tissue oxygenation correlates with wound healing in diabetic patients. Hyperspectral imaging of tissue oxy and deoxy may predict the healing of diabetic foot ulcers (DFU) with high sensitivity and specificity based on information obtained from a single visit.

Chin et al. sought to determine if hyperspectral imaging could accurately assess the presence or absence of peripheral artery disease (PAD) and accurately predict PAD severity. (4) In their prospective study patients with lower extremity edema were excluded. Patients underwent hyperspectral imaging at nine angiosomes on each extremity. Additional sites were imaged when tissue loss was present. Patients were separated into no-PAD and PAD groups.

Differences in hyperspectral values between the groups were evaluated using the two-tailed t test. Analysis for differences in values over varying severities of PAD, as defined by triphasic, biphasic, or monophasic Doppler waveforms, was conducted using one-way analysis of variance. Hyperspectral values were correlated with the ABI using a Pearson bivariate linear correlation test. The study enrolled 126 patients (252 limbs). After exclusion of 15 patients, 111 patients were left for analysis, including 46 (92 limbs) no-PAD patients and 65 (130 limbs) PAD patients. Groups differed in age, diabetes, coronary artery disease, congestive heart failure, tobacco use, and insulin use. Deoxyhemoglobin values for the plantar metatarsal, arch, and heel angiosomes were significantly different between patients with and without PAD ($P < .005$). Mean deoxyhemoglobin values for the same three angiosomes showed significant differences between patients with monophasic, biphasic, and triphasic waveforms ($P < .05$). In patients with PAD, there was also significant correlation between deoxyhemoglobin values and ABI for the same 3 angiosomes ($P = .001$). Oxyhemoglobin values did not predict the presence or absence of PAD, did not correlate with PAD severity, and did not correlate with the ABI. The authors concluded the results suggest the ability of hyperspectral imaging to detect the presence of PAD; and hyperspectral measurements can also evaluate different severities of PAD.

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Flowsense™

Effective Date: 01/01/2021
Updates: 05/15/2025
Review: 01/15/2023

Flowsense™	0639T

Flowsense™ is a wireless, noninvasive thermal flow sensor that can be mounted on a patient's neck overlying a ventricular shunt placed to treat hydrocephalus to detect the presence and magnitude of cerebrospinal fluid (CSF). Composed of soft silicone, there are no hard edges and is similar in size to a bandage. Data is wirelessly transmitted to a custom designed mobile app. (1)

A development article published by Krishnan et al. in 2020 looked at the use of a wearable, wireless sensor placed on 7 hydrocephalus patients. (2) According to the article, a Bluetooth Low-Energy System on a Chip (BLE-SoC) embedded system architecture allowed for robust, high quality data transfer during normal patient activities, where a miniaturized on-board, rechargeable battery supports continuous operation for several hours. On-body measurements and field trials on those patients revealed reliable operation during both spot-checks and extended measurements of flow during natural motions of the body as well as for different orientations. The authors state the results suggest broad applicability for monitoring of shunts in patients across age ranges, pathologies, and settings, including the home.

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Noncontact Near-Infrared Spectroscopy Studies of Flap or Wound

Effective Date: 07/01/2021
Updates: 05/15/2025
Review: 01/15/2023

Noncontact near-infrared spectroscopy studies of flap or wound (e.g., SnapshotNIR™)	0640T; 0859T

Oxygen plays an integral role in all phases of the wound healing process, with adequate tissue oxygenation being a key determinant of successful wound healing. The U.S. Food and Drug Administration (FDA) approved the SnapshotNIR™ under the 510(k) clearance process as a non-invasive tissue oxygenation measurement system. Using a near-infrared (NIR) reflectance-based technology, SnapshotNIR™ measures relative amounts of oxygenated and deoxygenated hemoglobin in the microcirculation where oxygen exchange is happening, purportedly providing users with a tissue oxygenation map that can be used in medical decision making (i.e., for tracking and trending oxygenation, and for evaluating tissue viability). (1, 2)

In a 2019 Product Brief, ECRI did not identify any relevant clinical studies published as full articles to inform decision about how well the SnapshotNIR™ non-invasive tissue oxygenation measurement system works for plastic surgery procedures or how it compares to similar products. (Evidence is inconclusive) (3)

Hill et al. (2020) undertook a pilot study to evaluate the capacity of NIR spectroscopy to detect clinically relevant differences is tissue perfusion intraoperatively. (4) Patients undergoing oncologic resection of breast cancer, sarcomas, and cutaneous tumors requiring flap reconstruction (local, regional, or free) between January 2018 and January 2019 were analyzed in this study. Clinicians were blinded to device tissue oxygen saturation (StO2) measurements taken intraoperatively after closure and at follow-up appointments in the first 30 days.

Measurements were categorized as 1) control areas not affected by the procedure, 2) areas at risk, and 3) areas of necrosis. These areas were retrospectively demarcated by 2 blinded assessors on follow-up images and transposed onto anatomically correlated intraoperative StO2 measurements. Mean StO2 values were compared using a single-sample *t* test and analysis of variance (ANOVA) to determine differences in oxygenation. Forty-two patients were enrolled, and 51 images were included in the analysis. Oncologic procedures were predominantly breast (22), post-extirpative melanoma (13), and sarcoma (3) reconstructions. Flap reconstruction involved 30 regional skin flaps, 3 pedicled flaps, and 3 free flaps. Nine patients (20.9%) and 11 surgical sites developed skin flap necrosis (SFN). Mean intraoperative StO2 measurements for control areas, areas at risk, and areas of SFN were 74.9%, 71.1%, and 58.3%, respectively. Relative to control areas, mean intraoperative StO2 measurements were lower by 17.5% (*P* = 0.01) in ultimate areas of SFN and in areas at risk by 5.8% (*P* = 0.003). Relative to areas at risk, mean StO2 measurements from areas of ultimate SFN were lower by 8.3% (*P* = 0.04). These preliminary data suggest that measuring skin flap tissue oxygenation intraoperatively, with NIR spectroscopy, can differentiate objective variations in perfusion that are associated with clinical outcomes.

Serena et al. (2020) conducted a pilot study comparing measurement of tissue oxygenation of NIR spectroscopy with transcutaneous oxygen measurement (TCOM) in patients with acute and hard-to-heal wounds. (5) The Shapiro-Wilk test was used to evaluate the normality of the data. The level of agreement between NIR spectroscopy and TCOM was determined using Bland-Altman analysis. The relationship between TCOM and NIRS was examined using Pearson correlation. A total of 24 observations were obtained from 10 patients using TCOM and NIR spectroscopy. The weighted mean partial pressure of oxygen (pO) in the study population was 39.54mmHg (8.96 standard deviation). Bland-Altman analysis showed that mean difference was positive (18.75), suggesting an overestimation of oxygen measurements using TCOM compared with NIR spectroscopy. The oxygen levels measured by TCOM and NIR spectroscopy showed a strong correlation (r=0.74). The wound and hyperbaric community would benefit from a simplified procedure for measuring tissue oxygenation. These findings suggest a strong trend toward correlation between NIR spectroscopy and TCOM. A further study in a larger population is recommended.

Moritz et al. (2023) enrolled patients receiving immediate alloplastic reconstruction after mastectomy or autologous reconstruction. (6) Preoperative, intraoperative, and postoperative images were taken of the flaps. Tissue oxygen saturation (StO_2) and hemoglobin were measured at the following locations: superior and inferior breast, free flap skin paddle (when applicable), and un-operated control skin. Linear mixed effects model for repeated measurements was used to model measurements to estimate the area effect difference across time, time effect difference across area, and pairwise comparisons between two areas at each time point. Thirty-two breasts underwent alloplastic reconstruction; 38 breasts underwent autologous reconstruction. No enrollees developed skin necrosis. StO_2 was highest after mastectomy and closure in alloplastic reconstructions. StO_2 was observed to decline at follow-up in autologous reconstructions. Mean preoperative StO_2 was highest in breasts that had previously undergone mastectomy and alloplastic reconstruction. The SnapshotNIR device detected normal spatial

and temporal differences in tissue oxygenation over the operative course of alloplastic and autologous breast reconstruction. A multi-institutional, prospective clinical trial is needed to determine the sensitivity and specificity of this device for detecting skin flap necrosis.

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Transcatheter Left Ventricular Restoration Device Implantation
Effective Date: 07/01/2021
Updates: 05/15/2025
Review: 01/15/2023

Transcatheter left ventricular restoration device implantation	0643T

The Less Invasive Ventricular Enhancement (LIVE) procedure is based on a law of physics which describes how the shape and pressure inside of the left ventricle can create stress on the heart. Heart failure symptoms worsen as the stress on the left ventricle increases, and the only way to stop the progression of heart failure is to reduce the stress on the left ventricle. The LIVE procedure is designed to reduce this wall stress by restoring the functionality of the left ventricle. (1)

Performed by both an interventional cardiologist and cardiac surgeon, the LIVE procedure uses the Revivent TC™ Ventricular Enhancement System to implant micro-anchor pairs into the scar tissue of the heart. The internal anchor is placed inside the right ventricle" of the heart through the jugular vein in the neck. The external anchor is placed on the outside of the left ventricle through a small incision on the left side of the chest. Once the anchors are in position, they are pulled toward each other resulting in the anchor pairs excluding the scar tissue from the healthy tissue on the left ventricle. This isolates the nonfunctioning part of the heart muscle and allows the remaining healthy tissue to work more effectively. An average of 2-3 anchor

pairs are typically implanted and remain in the heart once the procedure is finished. Currently, the LIVE procedure is performed in the U.S. at participating clinical trial centers as part of an investigational study. (1)

According to a 2022 ECRI Evidence Analysis, the AccuCinch Ventricular Restoration System is another implantable device intended to improve heart structure and function in patients with heart failure with reduced ejection fraction who have symptoms despite optimal medical therapy or cardiac resynchronization therapy, but do not require or do not qualify for a left ventricular assist device or heart transplant. A cardiovascular surgeon places the device percutaneously into a patient's enlarged left ventricle, anchors the AccuCinch implant into the left ventricle wall, and cinches it to reduce the left ventricle's size, and secures it with a nitinol lock. Currently the literature consists mainly of early feasibility studies with small sample sizes and only short-term follow-up. (2)

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Transcatheter Implantation of Coronary Sinus Reduction Device
Effective Date: 07/01/2021
Updates: 05/15/2025
Review: 01/15/2023

Transcatheter implantation of coronary sinus reduction device	0645T

Refractory angina is a debilitating condition that affects millions globally. Currently CE marked in Europe, the Neovasc Reducer™ is a wire mesh implanted into a vein in the heart. It provides relief of angina symptoms by altering blood flow within the myocardium of the heart and increasing the perfusion of oxygenated blood to ischemic area of the heart muscle. The device is placed using a minimally invasive transvenous procedure that is similar to implanting a coronary stent and is completed in approximately 20 minutes. (1) In January 2021, Neovasc Inc. announced that it had received a not-approvable letter from the FDA regarding its premarket approval submission for the Neovasc Reducer for the treatment of refractory angina. (2)

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Topical Gastrointestinal Hemostatic Agent (e.g., Hemospray® Endoscopic Hemostat Device)
Effective Date: 05/15/2021

Updates: 05/15/2025
Review: 01/15/2023

Topical gastrointestinal hemostatic agent (e.g., Hemospray® Endoscopic Hemostat device)	C1052

The Hemospray® Endoscopic Hemostat device is intended for hemostasis of non-variceal bleeds in the gastrointestinal (GI) tract. Hemospray is an inert, bentonite powder developed for endoscopic hemostasis. The powder is delivered by use of a carbon dioxide powered delivery system and through a catheter inserted through the working channel of an endoscope which provides access to the site of the bleed. (1)

In a September 2019 Product Brief, ECRI termed the evidence for treating intraluminal GI bleeding with Hemospray as "evidence raises concerns." Although studies suggest that Hemospray may work as well as standard treatments, they were of low quality, were at high risk of bias, and findings need validation in larger, multicenter, control ed trials. Additionally, there have been reports to the FDA describing serious device-related adverse events, raising concerns on risk of malfunction and serious injury. (2)

Alzoubaidi et al. (2020) reported on patients' outcomes after treatment with Hemospray from an international multicenter registry. (3) Prospective data (Jan 2016-May 2018) from 12 centers across Europe were collected. Immediate hemostasis was defined as endoscopic cessation of bleeding within 5 minutes after application of Hemospray. Rebleeding was defined as subsequent drop in hemoglobin, hematemesis, persistent melena with hemodynamic compromise post-therapy. Three hundred and fourteen cases were recruited worldwide (231 males, 83 females). Median pretreatment Blatchford score was 11 (IQR: 8-14) and median complete Rockall score (RS) was 7 (IQR: 6-8) for all patients. Peptic ulcer disease (PUD) was the most common pathology (167/314 = 53%) and Forrest Ib the most common bleed type in PUD (100/167 = 60%). 281 patients (89.5%) achieved immediate hemostasis after successful endoscopic therapy with Hemospray. Rebleeding occurred in 29 (10.3%) of the 281 patients who achieved immediate hemostasis. Seven-day and 30-day all-cause mortality were 11.5% (36/314) and 20.1% (63/314), respectively (lower than the predicted rates as per the RS). Similar hemostasis rates were noted in the Hemospray monotherapy (92.4%), combination therapy (88.7%) and rescue therapy (85.5%) groups. Researchers concluded that these data show high rates of immediate hemostasis overall and in all subgroups. Rebleeding and mortality rates were in keeping/lower than predicted rates.

In a 2020 systemic review, Aziz et al. assessed the efficacy of Hemospray in patients with non-variceal upper GI bleeding. (4) A total of 20 studies with 1280 patients were included in the final analysis. Technical success of Hemospray was seen in 97% of cases (95% confidence interval [CI] 94-98%, *I* =52.89%) and a significant trend towards increasing technical success was seen during publication years 2011-2019. Clinical success of Hemospray was seen in 91% of cases (95% CI 88-94%, *I* =47.72%), compared to 87% (95% CI 75-94%, *I* =0.00%) for other hemostatic measures. The secondary outcomes of aggregate rebleeding, early rebleeding, delayed

rebleeding, refractory rebleeding, mortality and treatment failure following the use of Hemospray were seen in 27%, 20%, 9%, 8%, 8%, and 31% of cases, respectively. The review had several limitations, including inclusion of only 2 randomized controlled trials (RCTs), inclusion of studies with a non-randomized designed which introduced possible selection bias, inability to identify the impact of Hemospray as monotherapy, in combination with other agents, or as a rescue agent, inconsistent identification of bleeding sources, and subjective self-reporting data from endoscopists of varying expertise. Future research, including RCTs and large cohort studies, are needed to specifically compare Hemospray to other hemostatic powders, as well as to other individual, mechanical modalities.

Baracat et al. (2020) conducted a pilot RCT with patients that presented with an active non-variceal upper GI bleeding lesion. (5) Patients were randomized either to the Hemospray or Hemoclip group. The randomization list was generated by a computer program and remained unknown throughout the entire trial. All patients underwent second-look endoscopy. Thirty-nine patients were enrolled. Peptic ulcer was the most frequent etiology. Primary hemostasis was achieved in all Hemospray cases and in 90% of Hemoclip group ($p = 0.487$). Five patients in Hemospray group underwent an additional hemostatic procedure during second-look endoscopy, while no patient in the Hemoclip group needed it ($p = 0.04$). Rebleeding, emergency surgery and mortality rates were similar in both groups. No toxicity, allergy events, or gastrointestinal obstruction signs were observed in Hemospray group.

Chahal et al. (2020) conducted a retrospective cohort study of Hemospray use, analyzing outcomes of hemostasis, rebleeding, need for embolization or surgery, and death. (6) Eighty-six applications of Hemospray were identified. The most common etiology of upper GI bleeds were ulcers (67.1%) whilst the etiology of lower GI bleeds varied. Hemospray was applied as monotherapy in 28 procedures (32.6%). Immediate hemostasis rate was 88.4%, but there was a high rate of re-bleeding (33.7%). Most re-bleeds occurred within 7 days (86.2%). Syncope was an independent predictive factor re-bleeding at 7 days for EGD (OR = 12.16, 95% CI, 1.51-97.75, P = 0.019). Bleeding refractory to endoscopic treatment with Hemospray required radiological embolization in 9 instances, and surgery in 9 instances. Hemospray therapy was protective against need for embolization ($p < 0.05$). Researchers concluded that Hemospray is effective in achieving immediate hemostasis but is plagued by high rates of rebleeding.

Hussein et al. (2020) prospectively collected data on the use of Hemospray from 16 centers. (7) Hemospray was used during the presence of progressive intraprocedural bleeding post-endoscopic therapy as a monotherapy, dual therapy with standard hemostatic techniques or rescue therapy once standard methods had failed. Hemostasis was defined as the cessation of bleeding within 5 minutes of the application of Hemospray. Re-bleeding was defined as a sustained drop in hemoglobin (>2 g/l), hematemesis or melaena with hemodynamic instability after the index endoscopy. A total of 73 patients were analyzed with bleeding post-endoscopic therapy. The median Blatchford score at baseline was five (interquartile range 0‑9). The median Rockall score was six (interquartile range 5‑7). Immediate hemostasis following the application of Hemospray was achieved in 73/73 (100%) of patients. Two out of 57 (4%) had a re-bleed post-Hemospray, one was following esophageal endoscopic mucosal resection and the other

post-duodenal endoscopic mucosal resection. Both patients had a repeat endoscopy and therapy within 24 h. Re-bleeding data was missing for 16 patients, and mortality data was missing for 14 patients. There were no adverse events recorded in association with the use of Hemospray. However, this was not an RCT; the decision to use Hemospray as a treatment modality was at the discretion of the endoscopist which could have contributed to selection bias. Additionally, there can be interobserver variability in the definition of immediate hemostasis after the application of Hemospray to the site of bleeding. Although it has a potential role as first-line therapy for bleeding at the end of a procedure rather than as a rescue therapy, larger RCT are required to validate these findings.

In a 2020 systematic review and meta-analysis, Mutneja et al. evaluated the efficacy of Hemospray in the management of upper GI bleeding. (8) A total of 11 prospective studies, including 4 randomized trials were included for the analysis. The pooled immediate hemostasis rate with Hemospray was 93% (95% CI 90.3-95%, p<0.001). Rebleeding occurred in 14.4% (95% CI 8.8-22.8%, p<0.001) of patients. For the subgroup of tumor-related bleeding, the immediate hemostasis rate was 95.3% (95% CI 89.6-97.3%; p <0.001) and rebleeding rate was 21.9% (95% CI 13.9-32.7%, p <0.001). In patients with variceal bleeding, immediate hemostasis was achieved in 92.7% (95% CI 83.6-96.9%; p<0.001) of patients, with a rebleeding rate of 3.1% (95% CI 0.9-10.2%, p <0.001). Reviewers concluded that Hemospray shows high immediate hemostasis and low bleeding percentages. The odds were in its favor compared to conventional endoscopic modalities, but not statistically significant. The results are undermined by the risk of bias in the studies. Nevertheless, it is an easy technique that should be further investigated with better studies.

Shah et al. (2024) conducted a systematic review and meta-analysis aimed to evaluate the efficacy and safety of Hemospray as a modality for primary hemostasis. (9) MEDLINE, CENTRAL, and CINAHL (Cumulative Index of Nursing and Allied Health Literature) databases were searched from inception to August 1, 2022. Three independent reviewers performed a comprehensive review of all original articles describing the application of Hemospray as the primary method of hemostasis in non-variceal upper GI bleeding patients. Three reviewers independently reviewed and abstracted data and assessed study quality using the Cochrane risk of bias tool. Primary outcomes were 1) primary hemostasis rate, 2) rebleeding rate until hospital discharge or death, 3) need for surgery, and 4) overall mortality rate. Of the 211 studies identified, 146 underwent title and abstract review, and four were included in the systematic review. Pooled results from 303 patients showed that compared to standard of care, Hemospray has significantly higher odds of primary hemostasis (OR: 3.48, 95% CI: 1.09-11.18, p = 0.04). There was no statistically significant difference in terms of rebleeding rates (OR: 0.79, 95% CI: 0.24-2.55, p = 0.69), need for surgery (OR: 1.62, 95% CI: 0.35-7.41, p = 0.54), or overall mortality (OR: 1.08, 95% CI: 0.56-2.08, p = 0.83). Authors concluded that this systematic review and meta-analysis suggests that Hemospray is a better modality of primary hemostasis in non-variceal upper GI bleeding when used as a primary method. At the same time, there is no significant difference in complications, including rebleeding, need for surgical intervention, and all-cause mortality. More randomized control trials should be undertaken so that more data are available to better define the outcomes of Hemospray as a primary hemostatic measure,

including rebleeding within 72 hours, mortality within 30 days, need for ICU admission, need for angiographic embolization, length of stay, and cost of hospitalization.

Practice Guidelines and Position Statements

In a 2020 update of the 2010 International Consensus Recommendation on the Management of Patients with Nonvariceal Upper Gastrointestinal Bleeding (10), the following statements were included:

- "In patients with actively bleeding ulcers, we suggest using TC-325 [hemostatic powder spray] as a temporizing therapy to stop bleeding when conventional endoscopic therapies are not available or fail (Grade: Conditional recommendation, very low-quality evidence)."
- "In patients with actively bleeding ulcers, we suggest against using TC-325 as a single therapeutic strategy versus conventional endoscopic therapy (clips alone, thermocoagulation alone, or combination therapy) (Grade: Conditional recommendation, very low-quality evidence)."

The American Gastroenterological Association issued a practice update on endoscopic therapies for non-variceal upper GI bleeding (2020) (11) which states: "Hemostatic power should be preferentially used as a rescue therapy and not for primary hemostasis, except in cases of malignant bleeding or massive bleeding with inability to perform thermal therapy or Hemoclip placement."

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Intravascular Lithotripsy
Effective Date: 05/15/2021
Updates:
Review: 01/15/2023, 05/15/2025

Intravascular lithotripsy (Shockwave Medical Intravascular Lithotripsy (IVL) System	C1761, C9764; C9765; C9766; C9767; C9772, C9773, C9774, C9775

The Shockwave Medical Intravascular Lithotripsy (IVL) System is intended for lithotripsy-enhanced balloon dilation of lesions, including calcified lesions, in the peripheral vascular. The device has integrated lithotripsy emitters and is designed to enhance percutaneous transluminal angioplasty by enabling delivery of the calcium-disrupting capability of lithotripsy prior to full balloon dilatation at low pressures. The application of lithotripsy mechanical pulse waves alters the structure of an occlusive vascular deposit (stenosis) prior to low-pressure balloon dilation of the stenosis and facilitates the passage of blood. (1)

In a July 2020 Clinical Evidence Assessment, ECRI termed the evidence for treating peripheral artery disease (PAD) with the Shockwave Peripheral Intravascular Lithotripsy System as "evidence is inconclusive: too few results on outcomes of interest". Although the five small case series ECRI reviewed reported high procedural success rates, reduced stenosis, and few serious events, the evidence was deemed to be at too high a risk of bias to support conclusions on the safety and effectiveness of the Shockwave device for treating PAD. Multicenter, randomized controlled trials (RCTs) that compare Shockwave to conventional angioplasty and other treatments for calcified PAD with are needed to validate these findings. (2)

In a prospective, nonrandomized, multicenter, single-arm industry-sponsored, observational study, Adams et al. (2020) assessed the acute safety and effectiveness of the Shockwave Peripheral IVL System for the treatment of calcified, stenotic lower limb arteries. In the 220 target lesions, IVL was more commonly used in combination with other balloon-based technologies (53.8%) and less often with concomitant atherectomy or stenting (19.8% and

29.9%, respectively). There was a 3.4-mm average acute gain at the end of procedure; the final mean residual stenosis was 23.6%. Angiographic complications were rare, with only 2 type D dissections and a single perforation following drug-coated balloon inflation (unrelated to the IVL procedure). There was no abrupt closure, distal embolization, no reflow, or thrombotic event. Use of peripheral IVL to treat severely calcified, stenotic PAD in a real-world study demonstrated low residual stenosis, high acute gain, and a low rate of complications despite the complexity of disease. (3)

Armstrong et al. (2020) evaluated the safety and efficacy of peripheral IVL during endovascular treatment of iliac arterial PAD. The Disrupt PAD III Observational Study is a prospective, non-randomized, multi-center single-arm study to assess the 'real-world' safety and effectiveness of the Shockwave Peripheral IVL System for the treatment of de novo calcified lesions in the peripheral arteries, with a goal of treating 1500 patients. This is an analysis of consecutive patients enrolled for treatment of an iliac artery, a specified sub-group, with at least moderate calcification and a minimum length of 20 mm. Between December 2017 and July 2019, 118 patients with a total of 200 lesions were enrolled across 20 sites. 101 patients were treated primarily for claudication or critical limb ischemia, while 17 patients were treated to optimize the iliac vasculature for large-bore access. All 118 patients had successful IVL catheter delivery. The average reference vessel diameter was 7.3 mm ± 1.9 mm, with an average diameter stenosis of 83.1% ± 13.4% and an average lesion length of 58.3 mm ± 57.6 mm. Severe calcification was present in 82.0% of overall cases. Stent placement was performed in 72.9% of the overall cases. As expected, the access group received less adjunctive therapies including stents (41.2%, $p < 0.001$). Angiographic complications were minimal with no flow-limiting dissections and a final mean residual stenosis of 12.0% ± 12.1% with no differences between the groups. (4)

Madhavan et al. (2020) performed an individual patient-level data (IPD) pooled analysis to evaluate the efficacy and safety of IVL in the treatment of PAD. Researchers pooled IPD, including baseline and procedural variables, from five prospective studies which assessed IVL in the treatment of patients with extensive peripheral artery calcification. Final postprocedural percent diameter stenosis (%DS) and procedural angiographic complications were assessed by independent core laboratory. Efficacy endpoints were analyzed using linear mixed effects models and safety endpoints were tabulated overall and by vascular bed. Among 336 patients who underwent endovascular revascularization with use of IVL, there was a significant reduction between pre-procedural and final %DS of 55.1% (95% confidence interval 53.3–57.0%, $p < .0001$). Core-laboratory assessed lesion-level complications, including flow-limiting dissections (Types D–F), vessel perforation, distal embolization, thrombus, abrupt closure, and no reflow, occurred in 4/328 (1.22%) of treated lesions. Authors concluded that the present IPD of five prospective studies, marking the largest analysis to date evaluating the use of IVL in significantly calcified PAD lesions, demonstrates this treatment strategy to be both effective and safe. However, the trials included in the analysis were single-arm studies with no comparators, so there is an inability to effectively compare the efficacy and safety of IVL with other endovascular PAD treatment devices. (5)

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Transoral Esophageal Mucosal Integrity Testing

Effective Date: 08/15/2021
Updates: 05/15/2025
Review: 01/15/2023

Transoral esophageal mucosal integrity testing by electrical impedance (e.g., MiVU™)	C9777

Historically, diagnostic testing for chronic esophageal disorders has relied on histopathology analysis of biopsies or uncomfortable transnasal catheters or wireless pH monitoring, to capture abnormal intraluminal reflux. (1) As an alternative, a balloon mucosal impedance (MI) catheter system called the MiVu™ Mucosal integrity Testing System that instantly detects changes in esophageal mucosal integrity during endoscopy, has been developed. (2)

In a prospective study, Patel et al. (2019) evaluated the ability of a balloon-incorporated MI catheter to detect and evaluate esophageal disorders, including gastroesophageal reflux disease (GERD) and eosinophilic esophagitis (EoE). (1) Sixty-nine patients undergoing esophagogastroduodenoscopy with or without wireless pH monitoring were classified as having GERD, EoE, or non-GERD. Receiver operating characteristic curves (ROC) and area under the ROC curve (AUC) were used to compare the accuracy of balloon MI in diagnosis. Probabilities of assignment to each group were estimated using multinomial logistic regression. MI pattern along the esophageal axis differed significantly ($p < 0.01$) among patients with GERD, EoE and non-GERD. Patients with non-GERD had higher MI values along all measured segments. The MI pattern for GERD was easily distinguished from that of EoE: in patients with GERD, MI values were low in the distal esophagus and normalized along the proximal esophagus, whereas in patients with EoE, measurements were low in all segments of the esophagus. Intercept and rate of rise of MI value (slope) as distance increased from the squamo-columnar junction identified

patients with GERD with an AUC = 0.69, patients with EoE with an AUC of 0.89, and patients with non-GERD with an AUC = 0.84 in the development cohort.

Study authors acknowledged that the study had some limitations. The prediction model assumed that subjects must belong to one of the three diagnosis groups, and uses an equal baseline prevalence of GERD, non-GERD, and EoE (35%, 35%, 30%) to estimate conditional (post-test) probability of the disease given MI intercept and slope. However, clinically, certain demographic and clinical symptoms can help augment the pre-test probability. For instance, studies have shown that clinical features that independently predicted EoE were younger age (<50 years), male, symptoms of dysphagia or history of food impaction, and documented food allergies/asthma. An ideal clinical prediction model would incorporate clinical characteristics to change the pre-test probability of a disease and then use balloon MI to provide more definitive post-test probability of the disease. However, this would require a very large sample size; investigators are now in the process of performing future studies using clinical characteristics in addition to balloon MI to augment the prediction model. It should also be noted that use of balloon MI should be avoided in patients with severe fibrostenotic disease that precludes safe expansion of the balloon catheter. The study also did not include patients with esophageal dysmotility.

Mutha et al. (2022) assessed whether two novel technologies, probe-based confocal laser endomicroscopy (pCLE) and mucosal integrity testing (MIT), could assess epithelial barrier function (EBF). (3) Patients undergoing upper endoscopy for refractory GERD or non-GERD conditions were prospectively enrolled. Patients underwent esophagogastroduodenoscopy, pCLE, MIT, esophageal biopsy at 2 cm and 6 cm above the esophagogastric junction, and wireless pH testing. To assess EBF in vitro, biopsies were mounted in a mini-Ussing chamber, 1 ml of fluorescein was instilled on the mucosal side, and concentration of fluorescein on the serosal side was measured at 3 h. Fifty-four subjects (28 GERD, 26 non-GERD based on Lyon consensus criteria) were enrolled. In vivo permeability assessed by pCLE did not differ significantly between GERD vs. non-GERD patients and did not correlate with in vitro permeability. Mean MIT at 2 cm was lower in GERD compared to non-GERD (1914 vs. 3727 ohms). MIT correlated inversely with in vitro permeability at 2 cm and at 6 cm. Using a predictive model that used slope and intercept of MIT at 2 cm and 6 cm, sensitivity and specificity of MIT at identifying GERD was 76% and 72%, respectively. pCLE did not differentiate GERD vs non-GERD and did not correlate with EBF measured in vitro. MIT, on the other hand, may be more promising as it differentiated GERD vs non-GERD and correlated with EBF measured in vitro.

The American College of Gastroenterology Clinical Guideline for the Diagnosis and Management of Gastroesophageal Reflux Disease (2022) (4) states “Mucosal integrity testing, e.g., is available commercially but is not developed sufficiently to warrant discussion in this guideline.”

The American Gastroenterological Association Clinical Practice Update on the Personalized Approach to the Evaluation and Management of GERD: Expert Review (2022) (5) does not address mucosal integrity testing.

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Assistive Algorithmic Electrocardiogram Risk-Based Assessment for Cardiac Dysfunction
Effective Date: 06/15/2023
Updates: N/A
Review: 05/15/2025

Assistive algorithmic electrocardiogram risk-based assessment for cardiac dysfunction	0764T, 0765T, C9786

Artificial intelligence is being applied to electrocardiogram (ECG) data for the autonomous generation of clinical conclusions and to aid in diagnosis.

In March 2022, Chen et al. (1) published results from a retrospective, single-center study. This study developed a deep learning model (DLM) to estimate ejection fraction (EF) via ECG (ECG-EF). They also investigated the relationship between ECG-EF and echo-based EF (ECHO-EF) and explored their contributions to future cardiovascular adverse events.

There were 57,206 ECGs with corresponding echocardiograms used to train the DLM. They compared a series of training strategies and selected the best DLM. The architecture of the DLM was based on ECG12Net, developed previously. Next, 10,762 ECGs were used for validation, and another 20,629 ECGs were employed to conduct the accuracy test. The changes between ECG-EF and ECHO-EF were evaluated. The primary follow-up adverse events included future ECHO-EF changes and major adverse cardiovascular events (MACEs).

The sex-/age-matching strategy-trained DLM achieved the best area under the curve (AUC) of 0.9472 with a sensitivity of 86.9% and specificity of 89.6% in the follow-up cohort, with a

correlation of 0.603 and a mean absolute error of 7.436. In patients with accurate prediction (initial difference < 10%), the change traces of ECG-EF and ECHO-EF were more consistent (R-square = 0.351) than in all patients (R-square = 0.115). Patients with lower ECG-EF (≤35%) exhibited a greater risk of cardiovascular (CV) complications, delayed ECHO-EF recovery, and earlier ECHO-EF deterioration than patients with normal ECG-EF (>50%). Importantly, ECG-EF demonstrated an independent impact on MACEs and all CV adverse outcomes, with better prediction of CV outcomes than ECHO-EF.

The ECG-EF could be used to initially screen asymptomatic left ventricular dysfunction (LVD) and it could also independently contribute to the predictions of future CV adverse events. Although further large-scale studies are warranted, DLM-based ECG-EF could serve as a promising diagnostic supportive and management-guided tool for CV disease prediction and the care of patients with LVD.

The authors also stated the following limitations: First, this study was a retrospective study from one institution. Although ECGs were collected in both outpatient and inpatient settings, further community-based prospective studies are necessary to validate the accuracy and application of ECG-EF. Second, the ECG characteristics found by CNN cannot be ascertained. It applies a set of methods that allows the model to be created using raw data for automatic identification of the features and relationships. Further interpretation of the algorithm and explanation of deep learning are needed. Third, novel optimization techniques proposed recently were not applied in this study, such as the Whale Optimizer or chimp optimization algorithm. These optimizers could provide better performance and increase the reliability of the network while maintaining its capability. Finally, the ECG-ECHO pairs were not simultaneously acquired. We collected all echocardiographic data seven days before or after the ECG exam, and 80% of the ECGs were collected within three days, restraining the errors related to temporal differences.

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Bioprosthetic Valve for Chronic Venous Insufficiency (VenoValve)
Effective Date: 06/15/2023
Updates: N/A
Review: 05/15/2025

Bioprosthetic valve for chronic venous insufficiency (VenoValve)	0744T

Chronic venous insufficiency (CVI) commonly affects the lower limbs. The venous valves that allow for lower limb blood to return to the heart fail, resulting in venous hypertension. A novel bioprosthetic valve for the deep venous system, VenoValve, has been developed by Hancock Jaffe Laboratories (Irvine, CA). The device components consist of a stainless-steel frame and a

porcine aortic monocusp leaflet that is sewn to the frame. The VenoValve is surgically implanted into the femoral vein in the mid-thigh region and secured with Prolene sutures to the native vein. The VenoValve is intended to open and close under physiologic pressure conditions within the deep venous system generated by the pressure or flow from calf muscle contracture. The VenoValve is designed to prevent or reduce the backflow or regurgitative volume of blood into the lower extremity venous system, thereby reducing the venous hypertension that develops in the diseased lower extremity. (1)

A one-year first-in-human feasibility study by Ulloa and Glickman was published in 2020. Ten patients with C5-C6 chronic venous insufficiency (CVI) of the deep venous system secondary to postthrombotic syndrome had a VenoValve surgically implanted into the femoral vein. Follow-up examinations were conducted postoperatively at 2 and 14 days and then every 30 days for 6 months. The results of the assessments for adverse events, reflux time, disease severity (venous clinical severity scores), pain scores (visual analog scale), and quality of life (QOL) (VEINES-QOL/Sym [venous insufficiency epidemiological and economic study–QOL/symptoms] questionnaire) were documented. (1)

Of the 10 patients, 9 had undergone VenoValve placement under regional anesthesia and 1 under local anesthesia. Six patients had required bovine patch angioplasty of the vein. Four adverse events occurred, including one case of hematoma at the incision site that was aspirated, 2 cases of superficial wound infection in C6 patients treated with antibiotics, and 1 case of a bleeding complication due to warfarin anticoagulation. One patient's VenoValve had thrombosed at 5 months due to nontherapeutic anticoagulation. Improvements in all 5 patients who had reached the 6-month follow-up mark with the VenoValve were demonstrated during the study period by decreases in the venous clinical severity scores (61% decrease from baseline), visual analog scale for pain scores (57% decrease), and reflux time (40% decrease) and a statistically significant improvement in the VEINES-QOL/Sym questionnaire. The patient with the occluded VenoValve had experienced improvements in all areas except for the reflux time. The latter patient had shown improvement because her ulcer had nearly healed before the occurrence of the thrombosis. (1)

Patients admitted to the study were those with failure of the best treatment options for CVI for ≥6 months before enrollment in the study. All but one patient had undergone ablation of the superficial system 6 months prior to VenoValve implantation with symptoms continuing. Exclusion criteria were C1 to C4 disease, acute DVT or pulmonary embolism, ongoing infection and an inability to ambulate.

The six patients who had reached the 6-month period had an average decrease in reflux time of 40%, with four of five patients returning to a normal reflux time of 0.05 second. All other patients had an average of 60% improvement in reflux time at the last follow-up examination. Patient enrollment was staggered; thus, not all the patients had reached the 6-month point. The venous clinical severity score (VCSSs) had improved by a mean of 61%, and the VAS scores had improved by 57%. Statistically significant improvement was seen in the VEINES-QOL/Sym scores at 6 months. The Sym (P = .022) and QOL (P = .0492) components both demonstrated

statistically significant progress compared with the preoperative levels. The average improvement in the VCSS was 8.3 points during the 6-month assessment. One patient, the first patient enrolled in the present study, had reached the 8-month follow-up point. The patient had continued to demonstrate or maintain improvement at the 8-month follow-up examination.

The authors concluded the VenoValve device could represent significant breakthrough technology that addresses an unmet medical need for patients experienced severe deep venous insufficiency. The VenoValve is a device that can be implanted in patients with CVI using standard surgical skills to restore venous valve function, return reflux to normal, reduce venous hypertension, and offer improved QOL to benefit a large population of patients. Although the results from implantation of this device are early and the current experience includes only one operation site, the results are promising. Limitations of this trial include a small number of patients as well as the short duration of follow-up. The early results of the first-in-human trial have demonstrated positive improvements that offer insight to developing a better treatment with successful clinical outcomes for these challenging cases.

A one-year follow up was published in 2022 by Ulloa and Glickman. (2) One-year clinical outcomes included significant decreases in mean reflux times (54%), and significant improvements in mean disease severity revised venous clinical severity score (56%), mean visual analog scale pain scores (76%), and Venous Insufficiency Epidemiologic and Economic Study QOL/sym scores. The promising results from this first-in-human (FIH) study demonstrate sustained safety and effectiveness of the VenoValve at 1-year post-implantation and support further study for its use as a novel treatment for severe, deep venous CVI caused by valvular incompetence. A pivotal, prospective, non-blinded, single-arm, multi-center study in the United States with 75 patients is in progress to assess the safety and effectiveness of VenoValve in these patients through 30 days and 6 months. The clinical trial is registered on ClinicalTrials.gov under identifier: NCT04943172.

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Virtual Reality Technology
Effective Date: 06/15/2023
Updates: 07/01/2023, 05/15/2025
Review: N/A

Virtual reality technology	0770T, 0771T, 0772T, 0773T, 0774T, 0791T, E1905

According to the U.S. Food and Drug Administration (FDA), virtual reality (VR) has the potential to transform health care by delivering new types of treatments and diagnostics and changing how and where care can be delivered. (1) This could allow for the delivery of some types of clinical services to patients in their homes or other non-clinical settings. It could also enable patients, including the socioeconomically vulnerable and underserved communities, the elderly or disabled, to access needed health care services when accessing in person would be difficult, making it easier and more likely for patients to complete treatment and monitoring regimens.

Benefits of utilizing virtual reality technology include improving health care professionals' abilities to prepare for certain treatments, increasing access to needed health care that otherwise might be difficult in person, mitigating preoperative anxiety, and allowing for self-directed care. Some potential risks include cybersickness, head and neck strain from the use of the headset device, cybersecurity and privacy risks, and distraction in the operating room. (1)

A 2016 review by Dockx et al. looked for the effectiveness of VR interventions for the rehabilitation of individuals with Parkinson's disease (PD) in comparison with active interventions and passive interventions. The primary goal was to determine the effect of VR training on gait and balance. (2) They identified 8 trials involving 263 people with PD. Risk of bias was unclear or high for all but one of the included studies. Sample sizes were small, and there was a large amount of heterogeneity between trials with regard to study design and the outcome measures used. As a result, the authors graded the quality of evidence as low or very low. Most of the studies intended to improve motor function using commercially available devices, which was compared to physiotherapy. Interventions lasted between 4 and 12 weeks. In comparison to physiotherapy, VR may lead to a moderate improvement in step and stride length (standardized mean difference [SMD] 0.69, 95% confidence interval [CI] 0.30 to 1.08; 3 studies; 106 participants; low-quality evidence). VR and physiotherapy interventions may have similar effects on gait (SMD 0.20, 95% CI -0.14 to 0.55; 4 studies; 129 participants; low-quality evidence), balance (SMD 0.34, 95% CI -0.04 to 0.71; 5 studies; 155 participants; low-quality evidence), and quality of life (mean difference 3.73 units, 95% CI -2.16 to 9.61; 4 studies; 106 participants). VR interventions did not lead to any reported adverse events, and exercise adherence did not differ between VR and other intervention arms. The evidence available comparing VR exercise with a passive control was more limited. The evidence for the main outcomes of interest was of very low quality due to the very small sample sizes of the two studies available for this comparison. Additional high-quality, large-scale studies are needed to confirm these findings.

Chau et al. in 2017 reported on the case of a patient with severe phantom limb pain following an upper limb amputation. (3) An interactive 3-D kitchen environment was developed based on the principles of mirror therapy to allow for control of virtual hands while wearing a motion-tracked, head-mounted virtual reality display. The patient used myoelectric control of a virtual

hand as well as motion-tracking control in this setting for five therapy sessions. Pain scale measurements and subjective feedback was elicited at each session. Analysis of the measured pain scales showed statistically significant decreases per session [Visual Analog Scale, Short Form McGill Pain Questionnaire, and Wong-Baker FACES pain scores decreased by 55 percent (p=0.0143), 60 percent (p=0.023), and 90 percent (p=0.0024), respectively]. Significant subjective pain relief persisting between sessions was also reported, as well as marked immersion within the virtual environments. On follow up at six weeks, the patient noted continued decrease in phantom limb pain symptoms. Currently available immersive virtual reality technology with myoelectric and motion tracking control may represent a possible therapy option for treatment-resistant phantom limb pain.

In 2016, Mirelman et al. sought to test the hypothesis that an intervention combining treadmill training with non-immersive VR to target both cognitive aspects of safe ambulation and mobility would lead to fewer falls than would treadmill training alone. (4) A randomized controlled trial was carried out this at five clinical centers across five countries (Belgium, Israel, Italy, the Netherlands, and the UK). Adults aged 60-90 years with a high risk of falls based on a history of two or more falls in the 6 months before the study and with varied motor and cognitive deficits were randomly assigned by use of computer-based allocation to receive 6 weeks of either treadmill training plus VR or treadmill training alone. Randomization was stratified by subgroups of patients (those with a history of idiopathic falls, those with mild cognitive impairment, and those with Parkinson's disease) and sex, with stratification per clinical site. Group allocation was done by a third party not involved in onsite study procedures. Both groups aimed to train three times per week for 6 weeks, with each session lasting about 45 minutes and structured training progression individualized to the participant's level of performance. The VR system consisted of a motion-capture camera and a computer-generated simulation projected on to a large screen, which was specifically designed to reduce fall risk in older adults by including real-life challenges such as obstacles, multiple pathways, and distracters that required continual adjustment of steps. The primary outcome was the incident rate of falls during the 6 months after the end of training, which was assessed in a modified intention-to-treat population. Safety was assessed in all patients who were assigned a treatment. Three hundred and two adults were randomly assigned to either the treadmill training plus VR group (n=154) or treadmill training alone group (n=148). Data from 282 (93%) participants were included in the prespecified, modified intention-to-treat analysis. Before training, the incident rate of falls was similar in both groups (10.7 [SD 35.6] falls per 6 months for treadmill training alone vs 11.9 [39.5] falls per 6 months for treadmill training plus VR). In the 6 months after training, the incident rate was significantly lower in the treadmill training plus VR group than it had been before training (6.00 [95% CI 4.36-8.25] falls per 6 months; p<0.0001 vs before training), whereas the incident rate did not decrease significantly in the treadmill training alone group (8.27 [5.55-12.31] falls per 6 months; p=0.49). Six months after the end of training, the incident rate of falls was also significantly lower in the treadmill training plus VR group than in the treadmill training group (incident rate ratio 0.58, 95% CI 0.36-0.96; p=0.033). No serious training-related adverse events occurred.

Peruzzi et al. (2017) examined the effect of a VR-based training on gait of people with multiple sclerosis in a single blind randomized controlled trial. (5) Twenty-five individuals with multiple sclerosis with mild to moderate disability were randomly assigned to either the control group (n = 11) or the experimental group (n = 14). The subjects in the control group received treadmill training. Subjects in the experimental group received VR-based treadmill training. Subjects in both the groups significantly improved the walking endurance and speed, cadence and stride length, lower limb joint ranges of motion and powers, during single and dual task gait. Moreover, subjects in the experimental group also improved balance, as indicated by the results of the clinical motor tests ($p < 0.05$). Between-group comparisons revealed that the experimental group improved significantly more than control group in hip range of motion and hip generated power at terminal stance at post-training.

Dockx et al. (2017) investigated attitudes of older adults toward fall prevention exercise with and without VR, including user satisfaction. (6) A total of 281 fall-prone older people were randomly assigned to an experimental group receiving treadmill training augmented by VR (TT+VR, n = 144) or a control group receiving treadmill training alone (TT, n = 137). Two questionnaires were used to measure 1) attitudes towards fall prevention exercise with and without VR (AQ); and 2) user satisfaction (USQ). AQ was evaluated at baseline and after intervention. USQ was measured after intervention only. The AQ revealed that most participants had positive attitudes towards fall prevention exercise at baseline (82.2%) and after intervention (80.6%; $p = 0.144$). In contrast, only 53.6% were enthusiastic about fall prevention exercise with VR at baseline. These attitudes positively changed after intervention (83.1%; $p < 0.001$), and 99.2% indicated that they enjoyed TT+VR. Correlation analyses showed that postintervention attitudes were strongly related to user satisfaction (USQ: $r = 0.503$; $p < 0.001$).

In a 2022 Clinical Evidence Assessment, ECRI characterized GaitBetter as “too few data on outcomes of interest” to answer the question as to how well GaitBetter works compared with other treatments for gait rehabilitation and fall prevention. (7) The available studies on GaitBetter are limited by a number of factors, including but not limited to, small patient populations, short follow-up, lack of functional mobility or other patient-oriented outcomes, and variation in patient characteristics and VR training protocols across studies. Additionally, the clinical relevance of the reported benefits of GaitBetter on gait parameters and fall prevention is unclear as no outcomes in the community setting have been reported.

Garcia et al. (2021) conducted a double-blind, parallel-arm, single-cohort, remote, randomized placebo-controlled trial for a self-administered behavioral skills-based VR program in community-based individuals with self-reported chronic low back pain during the COVID-19 pandemic. (8) A national online convenience sample of individuals with self-reported nonmalignant low back pain with duration of 6 months or more and with average pain intensity of 4 or more/10 was enrolled and randomized 1:1 to 1 of 2 daily (56-day) VR programs: 1) EaseVRx (immersive pain relief skills VR program); or 2) Sham VR (2D nature content delivered in a VR headset). Objective device use data and self-reported data were collected. The primary outcomes were the between-group effect of EaseVRx versus Sham VR across time points, and

the between-within interaction effect representing the change in average pain intensity and pain-related interference with activity, stress, mood, and sleep over time (baseline to end-of-treatment at day 56). Secondary outcomes were global impression of change and change in physical function, sleep disturbance, pain self-efficacy, pain catastrophizing, pain acceptance, pain medication use, and user satisfaction. Analytic methods included intention-to-treat and a mixed-model framework. The study sample was 179 adults (female: 76.5%, 137/179; Caucasian: 90.5%, 162/179; at least some college education: 91.1%, 163/179; mean age: 51.5 years [SD 13.1]; average pain intensity: 5/10 [SD 1.2]; back pain duration ≥5 years: 67%, 120/179). No group differences were found for any baseline variable or treatment engagement. User satisfaction ratings were higher for EaseVRx versus Sham VR (P<.001). For the between-groups factor, EaseVRx was superior to Sham VR for all primary outcomes (highest P value=.009), and between-groups Cohen d effect sizes ranged from 0.40 to 0.49, indicating superiority was moderately clinically meaningful. For EaseVRx, large pre-post effect sizes ranged from 1.17 to 1.3 and met moderate to substantial clinical importance for reduced pain intensity and pain-related interference with activity, mood, and stress. Between-group comparisons for Physical Function and Sleep Disturbance showed superiority for the EaseVRx group versus the Sham VR group (P=.022 and .013, respectively). Pain catastrophizing, pain self-efficacy, pain acceptance, prescription opioid use (morphine milligram equivalent) did not reach statistical significance for either group. Use of over-the-counter analgesic use was reduced for EaseVRx (P<.01) but not for Sham VR. Researchers concluded that EaseVRx had high user satisfaction and superior and clinically meaningful symptom reduction for average pain intensity and pain-related interference with activity, mood, and stress compared to sham VR, however additional research is needed to determine durability of treatment effects and to characterize mechanisms of treatment effects. For most primary and secondary outcomes, treatment effects for therapeutic VR showed durability, and maintained superiority to Sham VR in the 3-month post-treatment period. (9) Therapeutic VR maintained significant and clinically meaningful effects 6 months posttreatment and remained superior to sham VR for reducing pain intensity and pain-related interference with activity, stress, and sleep (d_s=0.44-0.54; P<.003). (10) Between-group comparisons for physical function and sleep disturbance showed superiority of EaseVRx over sham VR (d_s=0.34; P=.02 and d_s=0.46; P<.001, respectively). Future research should extend efficacy investigations for home-based VR to other pain conditions and diagnoses, as well as examine mechanisms of treatment effects in real-world patient populations.

A 2022 ECRI clinical evidence assessment found the evidence for virtual reality-based psychological and behavioral intervention for treating chronic back pain to be inconclusive due to small size, lack of randomization and short follow-up duration. (11)

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Surface Mechanomyography
Effective Date: 06/15/2023
Updates: N/A
Review: 05/15/2025

Surface mechanomyography	0778T

Surface mechanomyography uses multi-sensor technology which quantifies joint motion and muscle function and includes calibration of the sensors, set-up and placement over bony landmarks and specific muscle groups. Augmentative measurement and analysis of joint motion and muscle function is performed during functional activities (e.g., sit to stand to sit, gait). Post assessment, the data is synced within a secure platform, and a report is generated.

A paper published in 2019 by Woodward et al. included 5 individuals. The study used an exerting squat-based task to induce muscle fatigue. Mechanomyography (MMG) and

electromyography (EMG) amplitude and frequency were compared before, during, and after the squatting task. Combining MMG with inertial measurement unit (IMU) data enabled segmentation of muscle activity at specific points: entering, holding, and exiting the squat. Results show MMG measures of muscle activity were similar to EMG in timing, duration, and magnitude during the fatigue task. The size, cost, unobtrusive nature, and usability of the MMG/IMU technology used, paired with the similar results compared to EMG, suggest that such a system could be suitable in uncontrolled natural environments such as within the home. (1)

A 2018 study by Krueger et al. looked at 6 spinal cord-injured male volunteers with no voluntary control of the quadriceps muscle. Electrical bursts of voltage-controlled monophasic square pulses at frequencies of 1 kHz (50% duty cycle) at 50 Hz (15% duty cycle) were used to generate thigh muscle contractions that controlled the knee joint in the sagittal plane. The pulse amplitudes were set to position the knee joint at a 5° angle from the horizontal plane and when the knee angle dropped to 20° (e.g., the quadriceps were unable to hold the lower leg in the desired position), the test was terminated. Two data segments lasting 10 seconds each, at the beginning and end of each test, were analyzed. The muscle contraction was assessed by MMG sensors positioned on the rectus femoris, vastus lateralis, and vastus medialis muscles. Data segments were decomposed into 11 frequency bands using a Cauchy wavelet transform. In the initial time interval (non-fatigued muscle), the power peak was concentrated in the 11.31 Hz frequency band. In the final interval (muscle fatigued) this peak shifted to lower frequencies (2 and 6 Hz frequency bands). The decreased frequency was most prominent during the last 4 seconds of the recordings. It was shown that MMG could be used as a real-time indicator of muscle fatigue during functional electrical stimulation (FES)-induced isometric contraction of quadriceps; hence, MMG could be used in closed-loop control as a fatigue detector. Subsequent studies for non-isometric contractions could possibly lead to prediction of muscle fatigue before contractile failure during functional use of the muscle. (2)

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Real-Time Pressure-Sensing Epidural Guidance System (CompuFlo®)
Effective Date: 06/15/2023
Updates: N/A
Review: 05/15/2025

Real-time pressure-sensing epidural guidance system (CompuFlo®)	0777T

CompuFlo® (Milestone Scientific, Livingston, NJ) is an epidural spinal needle placement using a software system that integrates artificial intelligence to place an epidural needle. Per the

manufacturer, CompuFlo® has a sensor which interprets epidural pressures, details anatomical needle placement and measures precise saline volume via software facilitating data transmission to an epidural system console screen. This software analyzes the data allowing the practitioner to place the epidural spinal needle. (1)

The U.S. Food and Drug Administration (FDA) approved CompuFlo® in 2017 based on a predicate device. Per the FDA approval, The CompuFlo® Epidural Computer Controlled Anesthesia System is intended for use with an epidural needle for the real-time verification of needle tip placement in the lumbar epidural space in patients over age of 18 who are required to have epidural needle placement as part of a medically necessary, in-patient or out-patient procedure, as established by their health care provider (HCP). Once health care provider verifies the epidural needle placement in the lumbar epidural space, CompuFlo® Epidural Computer Controlled Anesthesia System is disconnected and the HCP continues with the medical procedure. (2)

In 2018, Capogna et al. published results from a prospective study designed to validate the CompuFlo device and to assess its use in difficult epidural placement in difficult obstetric cases. In the first part of the study, 30 parturients requesting labor epidural analgesia were recruited. The block was performed by an expert anesthesiologist, with the Tuohy needle connected to the CompuFlo® device to evaluate the agreement between the anesthesiologist's reported sensation and the variation of pressure recorded by the CompuFlo®. In the second part of the study, 56 consecutive parturients, for whom at least two complete needle reinsertions were made by trainees during epidural placement for labor analgesia, were enrolled. CompuFlo® was used as a rescue tool for the subsequent attempt. (3) In all cases epidural analgesia was successful and no complications were noted. There was a good correlation between the operator's feelings and the delta of pressure recorded by the CompuFlo®, for both identification of the ligamentum flavum and of the epidural space (Rho = 0.79; tau = 0.67). In the second part of the study, all the difficult blocks performed with the CompuFlo® were successful after a single attempt. The pressure curves of false loss-of-resistance were significantly different from the true loss-of-resistance ($P < 0.0001$). Per the authors, CompuFlo® was validated as a tool to identify the epidural space. It may also assist trainees in successful epidural placement in difficult cases.

A 2020 single-center retrospective study published by di Filippo et al. included 141 women from Jan. to Dec. 2017. In 85% of cases, the epidural catheter was correctly positioned within the first two attempts. The average time of the procedure was 76.07 sec (range 48.9-98.15). A third attempt was necessary in 15% of cases. Of the 141 patients who underwent the catheter positioning using CompuFlo®, none developed complications. All the epidural blocks worked properly. CompuFlo® epidural system seems to be effective and safe in identifying the epidural space, also in difficult cases, minimizing the incidence of adverse events. Our retrospective study needs to be validated by larger RCTs. (4)

A 2019 case series out of Germany by Helf et al. reported on a series of 24 epidural procedures using the CompuFlo device in German-speaking countries. The epidural space was successfully

identified in 23 cases. Conversion to the conventional loss of resistance technique was performed during the initial cases in a prolonged procedure. The CompuFlo® technique is considered to be a promising technology, which might help to reduce complications after epidural anesthesia, e.g., postdural puncture headache. (5)

A 2019 prospective randomized controlled noninferiority trial by Gebhard et al. compared CompuFlo with fluoroscopy and traditional loss of resistance. A total of 400 patients were enrolled. In the chronic pain (CP) management arm, 240 patients scheduled to receive a lumbar epidural steroid injection had their epidural space (ES) identified either with fluoroscopy (FC) or with needle-tip pressure measurement. In the labor and delivery (L&D) arm, 160 female patients undergoing lumbar epidural catheter placements were randomized to either loss of resistance (LOR) or needle-tip pressure measurement. Blinded observers determined successful ES identification in both arms. A modified intention-to-treat protocol was implemented, with patients not having the procedure for reasons preceding the intervention excluded. Noninferiority of needle-tip pressure measurement regarding the incidence of successful ES identification was claimed when the lower limit of the 97.27% confidence interval (CI) for the odds ratio (OR) was above 0.50 (50% less likely to identify the ES) and P value for noninferiority <.023. (6) Demographics were similar between procedure groups, with a mild imbalance in relation to gender when evaluated through a standardized difference. Noninferiority of needle-tip pressure measurement was demonstrated in relation to FC where pain management patients presented a 100% success rate of ES identification with both methodologies (OR, 1.1; 97.27% CI, 0.52–8.74; P = .021 for noninferiority), and L&D patients experienced a noninferior success rate with the novel technology (97.1% vs 91%; OR, 3.3; 97.27% CI, 0.62–21.54; P = .019) using a *a priori* noninferiority delta of 0.50. Objective lumbar ES identification using continuous, quantitative, real-time, needle-tip pressure measurement with the CompuFlo Epidural Computer Controlled Anesthesia System resulted in noninferior success rates when compared to FC and LOR for CP management and L&D, respectively. Benefits of this novel technology may include nonexposure of patients to radiation and contrast medium and consequently reduced health care costs.

The authors also noted this study was solely designed to evaluate the capability of CEI (CompuFlo) technology to correctly identify needle-tip position within the ES. Because successful performance of epidural anesthesia/injections depends on many factors (e.g., correct placement of the epidural catheter and amount of local anesthetic used), no statements can be made regarding the impact of this novel technology on the overall success of epidural anesthesia or epidural injections. However, correct identification of needle-tip placement within the ES is the one prerequisite that must be fulfilled before further management can potentially determine the eventual success or failure of epidural anesthesia/injections. Another limitation of this investigation is that they did not specifically evaluate the CEI technology for ES identification under more challenging scenarios, such as ES identification in patients suffering from extreme obesity (BMI, >40), or when performing thoracic or cervical epidural anesthesia. Consequently, no conclusions can be drawn whether CEI is noninferior to SC for ES identification in such settings. Future research is needed to specifically investigate the potential synergistic effects of combining the CEI technology with US, the impact of real-time pressure

measurement at the Tuohy needle tip on the incidence of accidental dural puncture (ADP), as well as potential superiority regarding success rate when compared to traditional LOR. (6)

A clinical evidence assessment on CompuFlo published by ECRI in 2021 indicated inconclusive evidence is available. It stated that CompuFlo works as intended to identify the epidural space, but whether it is more effective than standard care cannot be determined from 3 cohort studies at high risk of bias. Evidence from 1 randomized controlled trial (RCT) and 4 case series shows that CompuFlo is safe, but procedural success is no better with CompuFlo than standard care. The RCT demonstrates CompuFlo is noninferior to LOR and fluoroscopy, but epidural space identification success rates were high in all groups and whether CompuFlo provides a benefit over standard care in patients receiving EA cannot be determined. Additional independent RCTs are needed to confirm findings and enable conclusions; 2 of 3 ongoing RCTs will address evidence gaps. The RCT has limited generalizability because authors did not specifically analyze patient (e.g., those who were obese) and epidural (e.g., thoracic, cervical) subgroups. The cohort studies and case series are at high risk of bias due to 2 or more of the following: small sample size, retrospective design, single-center focus, and lack of control groups or appropriate reference standards. Also, the cohort studies used different reference standards; 1 used LOR technique as reference method but involved a single operator; another used CompuFlo's detection of pressure drops. For 1 case series, anesthesiologist trainees used CompuFlo as a rescue option after 2 failed epidural attempts, and this approach may not generalize to routine practice by experienced practitioners. (7)

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Darvadstrocel (Alofisel)
Effective Date: 06/15/2023
Updates: N/A
Review: 05/15/2025

Darvadstrocel (Alofisel)	0748T

Darvadstrocel (Alofisel) is a suspension of allogeneic (or donor-derived) expanded adipose-derived stem cells (eASC) for the treatment of complex perianal fistulas in adult patients with non-active or mildly active luminal Crohn's disease (CD). According to the manufacturer, Takeda Pharmaceuticals, the product is injected into tissue around a perianal fistula vs. into the fistula itself. (1) Darvadstrocel received an orphan drug designation from Japan's Ministry of Health, Labour and Welfare on March 13, 2019, for potential efficacy, effects, or performance in treating complex perianal fistulas in adult patients with CD. Darvadstrocel received central marketing authorization approval in Europe in March 2018 for the treatment of complex perianal fistulas in adult patients with non-active/mildly active luminal CD. It was granted orphan drug designation by the U.S Food and Drug Administration (FDA) in 2017, and in 2019, darvadstrocel received a Regenerative Medicine Advanced Therapy (RMAT) designation from the FDA for complex perianal fistulas in adults with CD. (1)

Zmora et al. reported on a 6-month interim analysis from an observational post-marketing registry on the effectiveness and safety of darvadstrocel (Alofisel; DVS) in patients with Crohn's disease and complex perianal fistulas. (2) As of September 2021, 230 patients had enrolled in the ongoing study. The All Treated (AT) cohort consisted of all patients in the study who received Alofisel; the Treated Per Protocol (PP) cohort consisted of all patients in the study who received Alofisel according to protocol recommendation. One hundred thirty-eight patients in the All Treated (AT) cohort and 120 patients in the Treated Per Protocol (PP) cohort were six-months post treatment and 66% for AT (92/138) and 58% for PP (69/120) had a six-month visit completed. Among them, 85% (78/92) of the AT cohort and 100% (69/69) of the PP cohort had clinical outcome data available at six-months. Clinical response was observed in 73% (57/78) and 74% (51/69) of patients in the AT and PP cohorts, respectively. Clinical remission was observed in 65% of patients in both cohorts (AT cohort: 51/78; PP cohort: 45/69). This is the first real-world, multi-center study reporting the effectiveness and safety data after DVS treatment for complex Crohn's perianal fistulas (CPF). These interim analysis data are consistent with the pivotal ADMIRE-CD study in terms of effectiveness and safety. The ongoing status of the registry and small number of evaluable patients mean these data should be interpreted with caution, pending future analyses in larger numbers of patients with longer follow-up times. (2)

In 2021, Schwandner published results from a single-center experience; between July 2018 and Jan. 2021, 12 patients underwent stem cell therapy. All patients had a minimum of one complex fistula, including patients with two complex fistulas in 58.3% (7/12). Two of the 12 patients had horse-shoe fistula and 3 had one complex fistula. According to Parks classification, the majority of fistulas were transsphincteric (76%) or suprasphincteric (14%). All patients underwent

removal of seton, fistula curettage, transanal closure of internal opening by suture (11/12) or mucosal flap (1/12) and stem cell injection. At a mean follow-up of 14.3 (range: 3-30) mo, a healing rate was documented in 66.7% (8/12); mean duration to achieve healing was 12 (range: 6-30) wk. Within follow-up, 4 patients required reoperation due to perianal abscess (33.3%). Focusing on patients with a minimum follow-up of 12 mo. (6/12) or 24 mo. (4/12), long-term healing rates were 66.7% (4/6) and 50.0% (2/4), respectively. The author concluded data are promising but limited due to the small number of patients and retrospective analysis; further prospective controlled studies are mandatory to assess the definite role of adipose-derived mesenchymal stem cells for complex anal fistula in Crohn's disease. (3)

Garcia-Olmo et al. (2022) published results of a phase 3 double blind randomized-controlled study (ADMIRE-CD) in patients with perianal fistulizing Crohn's disease. The goal of this study was to assess the long-term safety and efficacy of darvadstrocel at 2 years post-treatment in patients with Crohn's disease and complex perianal fistulas. This study extension was conducted in multiple hospitals across 7 European countries and Israel. Forty patients entered the extended follow-up period: 25 patients in the darvadstrocel treatment group and 15 in the control group. Treatment-emergent serious adverse events were recorded through week 104. Clinical remission, defined as closure of all treated external openings that were draining at baseline despite gentle finger compression, was assessed at week 104. Of 40 patients, 37 completed the extended follow-up. Through week 104, 7 treatment-emergent serious adverse events were reported, of which 4 occurred between weeks 52 and 104. At week 104, clinical remission was reported in 14/25 (56%) patients in the darvadstrocel group and 6/15 (40%) patients in the control group. Limitations include the small number of patients who entered the extended follow-up period, and no imaging examinations were performed at the 104-week time point. Darvadstrocel was well tolerated and clinical remission after treatment with darvadstrocel may be sustained for up to 104 weeks in patients with perianal fistulizing Crohn's disease. (4)

In Nov. 2022, Panes et al. published results from INSPECT, a retrospective study to evaluate long-term effectiveness and safety of patients with perianal fistulizing CD treated in the ADMIRE-CD trial. Eligible patients had completed at least 52 weeks in the ADMIRE-CD trial. Data on clinical remission and fistula relapse outcomes were collected retrospectively at 104 and 156 weeks after treatment. Adverse events of special interest (tumorigenicity and ectopic tissue formation) were collected up to 208 weeks after treatment. Eighty-nine patients were included (43 darvadstrocel patients, 46 control subjects). At 52, 104, and 156 weeks posttreatment, clinical remission was observed in 29 (67.4%) of 43, 23 (53.5%) of 43, and 23 (53.5%) of 43 darvadstrocel-treated patients, compared with 24 (52.2%) of 46, 20 (43.5%) of 46, and 21 (45.7%) of 46 control subjects, respectively. In patients with clinical remission at week 52, this remission was sustained at 104 and 156 weeks after treatment in 19 (65.5%) of 29 and 16 (55.2%) of 29 darvadstrocel-treated patients and in 17 (70.8%) of 24 and 13 (54.2%) of 24 control subjects, respectively. Time to fistula relapse and incidence of fistular elapse or new fistula occurrence were not significantly different between groups. Tumorigenicity was reported for 1 (2.2%) patient in the control group (malignant epidermoid carcinoma). No ectopic tissue formation was reported. Real-world follow-up of patients from the ADMIRE-CD

trial indicates that clinical remission of complex perianal fistulas can be sustained in the long term irrespective of whether it is achieved through darvadstrocel administration or maintenance treatment regimens and confirms a favorable long-term safety profile of darvadstrocel. (5)

In 2019, the National Institute for Health and Care Excellence (NICE) published a technology appraisal guidance on darvadstrocel for treating complex perianal fistulas in Crohn's disease. According to this guidance, darvadstrocel is not recommended, within its marketing authorization, for previously treated complex perianal fistulas in adults with non-active or mildly active luminal Crohn's disease. (6)

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Pulmonary Tissue Ventilation Analysis (e.g., XV Lung Ventilation Analysis Software System)
Effective Date: 07/01/2023
Updates: N/A
Review: 05/15/2025

Pulmonary tissue ventilation analysis (e.g., XV Lung Ventilation Analysis Software System)	0807T, 0808T

Earlier diagnosis and treatment can be assisted by more sensitive and accurate assessments of regional lung ventilation. Pulmonary tissue ventilation analysis using software-based image-processing technology is a new procedure that utilizes image processing technology to quantify ventilation of pulmonary function. Software-based processing is performed on data captured

from a separate cinefluorograph. The lung images are uploaded to an image routing system which identifies corresponding images from a previously obtained computed tomography (CT) scan of the chest. The images are then transmitted to an analysis engine for pulmonary ventilation analysis. From motion, ventilation is calculated at each stage of the breath and at every location within the lung. The ventilation measurements are then visualized as a colored heat-map to identify ventilation deficits. (1)

Currently, there is a lack of quality published literature on pulmonary tissue ventilation analysis using software-based image-processing technology. Most of the available publications are either animal studies or informational articles describing the technology itself. Wang et al. (2022) described these services in terms of tools being used in research and clinical settings that have yet to be consistently adopted for diagnostic work-up and treatment planning, and that "their full potential remains to be explored." (2)

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Intermittent Abdominal Pressure Ventilation Devices

Effective Date: 05/15/2025
Updates: N/A
Review: N/A

Intermittent abdominal pressure ventilation devices	A4468

Mechanical ventilation is a treatment to assist an individual to breathe when they find it difficult or are unable to breathe on their own. Common types include both invasive ventilation via endotracheal intubation or tracheostomy, and noninvasive ventilation such as continuous positive airway pressure (CPAP), autotitrating (adjustable) positive airway pressure (APAP), and bilevel positive airway pressure (BiPAP) that is delivered via a nasal or an oronasal mask. Recently there has been renewed interest in noninvasive ventilation utilizing intermittent abdominal pressure ventilator (IAPV) devices. With the use of these types of devices, a positive pressure is applied by intermittently inflating a bladder contained in a fabric corset that is placed around the patient's abdomen. Through this kind of assisted expiration, the diaphragm moves upwards until the bladder deflates and passive inspiration occurs by gravity.

Several case reports on the use of IAPV have been published over the years, (1-4) with one of the larger being Bach et al. (1991), who presented on the experience of 54 patients with paralytic/restrictive respiratory insufficiency using IAPV. (1) Forty-eight of the 54 patients used the IAPV for daytime support for a mean of 12.9 ± 11.5 years (3 months to 39 years). All 48

patients maintained normal minute ventilation and end-tidal partial pressure of carbon dioxide (PCO_2), on the IAPV. One patient used the IAPV only for nocturnal ventilatory support for six months. Five patients relied on the IAPV as their sole method of ventilatory support 24 hours a day for a mean of 13.4 ± 11.2 years (range, 2 to 31 years). The IAPV became ineffective for 12 patients after 12.3 ± 9.5 years of use. The authors concluded that IAPV is a safe and effective method of long-term daytime ventilatory supports for patients with paralytic/restrictive respiratory insufficiency but cautioned that regular follow-up is important because the IAPV can become less effective with time.

Pierucci et al. (2022) performed a narrative review by searching PubMed, Medline, and the Cochrane Database of Systematic Reviews using the terms "IAPV" or "pneumobelt." (5) One hundred forty patients were cited using the intermittent abdominal pressure ventilator from 1946 until it went off the market in the 1970s, although many continued to use it. There was only one publication on its use from 2003 to 2017, but three publications from 2017 through 2021. While it has been used for daytime support for more than 70 years, its knowledge among clinicians is scarce. Reviewers concluded that IAPV can be effective and well tolerated, giving patients the ability to maintain quality of life without facial interfaces.

Volpi et al. (2023) conducted a multicenter retrospective pilot study looking at the practicability and efficacy of IAPV in 28 neuromuscular patients. (6) Data were collected at baseline (T0) and after two hours of ventilation (T1), with follow-ups at three months (T2) and six months (T3). Statistical significance was found for $PaCO_2$ over time ($F [2.42] = 7.63$, $p = 0.001$) and PaO_2 ($W = 0.539$, $p = 0.033$). The time of usage also significantly affected the quality of life ($F (2.14) = 6.90$, $p = 0.010$), as seen when comparing T0 and T3. Limitations of the study includes the low sample size, which limits the possibility of generalizing the results. Another relevant limitation is the lack of a comparison between NVS and IAPV according to a randomized and controlled approach, which would have also helped to highlight a comparison between the criticalities of one device and the other.

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Cardiac Acoustic Waveform Recording With Automated Coronary Artery Disease Risk Score
Effective Date: 05/15/2025
Updates: N/A
Review: N/A

Cardiac acoustic waveform recording with automated coronary artery disease risk score	0716T

Heart disease is the leading cause of death for men and women in the United States (U.S.). (1) Heart disease is also the leading cause of death for people of most racial and ethnic groups in the U.S., including African American, American Indian, Alaska Native, Hispanic, and white men. For women from the Pacific Islands and Asian American, American Indian, Alaska Native, and Hispanic women, heart disease is second only to cancer. Coronary artery disease (CAD) is the most common type of heart disease in the U.S., killing more than 375,000 people per year. Angina is the most common symptom of CAD. Risk factors for CAD include being overweight, physical inactivity, poor diet, and smoking. A family history of heart disease also increases the risk for CAD, especially in cases where there is a family history of early onset heart disease (i.e., age 50 years or younger).

The CADScor System is a portable, bedside device developed to exclude suspected CAD. The CADScor works with sensitive microphones to record heart sounds, murmurs, and vibrations for calculation of a patient specific score, indicating the risk of presence of coronary stenosis, as an aid in cardiac analysis and diagnosis. The individual is purported to be risk stratified either to further testing or to a low probability of CAD with no need for additional testing. (2)

Winther et al. (2015) evaluated the diagnostic accuracy of an acoustic test (CAD-score) to detect CAD and compare it to clinical risk stratification and coronary artery calcium score (CACS). (3) Patients with symptoms of CAD referred to either coronary computed tomography or invasive coronary angiography (ICA) were enrolled. All patients were tested with the CAD-score system. Obstructive CAD was defined as more than 50% diameter stenosis diagnosed by quantitative analysis of the ICA. In total, 255 patients were included, and obstructive CAD was diagnosed in 63 patients (28%). Diagnostic accuracy evaluated by receiver operating characteristic curves was 72% for the CAD-score, which was similar to the Diamond–Forrester clinical risk stratification score, 79% ($p = 0.12$), but lower than CACS, 86% ($p < 0.01$). Combining the CAD-score and Diamond–Forrester score, area under the curve (AUC) increased to 82%, which was significantly higher than the standalone CAD-score ($p < 0.01$) and Diamond–Forrester score ($p < 0.05$). Addition of the CAD-score to the Diamond–Forrester score increased correct reclassification, categorical net-reclassification index = 0.31 ($p < 0.01$). This study demonstrates the potential use of an acoustic system to identify CAD. The combination of clinical risk scores and an acoustic test seems to optimize patient selection for diagnostic investigation.

Researchers stated that further validation in a prospective study has to be performed to confirm the findings.

Winther et al. (2018) tested the diagnostic accuracy of a new portable acoustic device for detection of CAD. (4) Study included 1675 patients with low to intermediate likelihood of CAD who had been referred for cardiac CT angiography. If significant obstruction was suspected in any coronary segment, patients were referred to invasive angiography and fractional flow reserve (FFR) assessment. Heart sound analysis was performed in all patients. A predefined acoustic CAD-score algorithm was evaluated; subsequently, researchers developed and validated an updated CAD-score algorithm that included both acoustic features and clinical risk factors. Low risk was indicated by a CAD-score value ≤20. Hemodynamically significant CAD assessed from FFR was present in 145 (10.0%) patients. In the entire cohort, the predefined CAD-score had a sensitivity of 63% and a specificity of 44%. In total, 50% had an updated CAD-score value ≤20. At this cut-off, sensitivity was 81% (95% CI 73% to 87%), specificity 53% (95% CI 50% to 56%), positive predictive value 16% (95% CI 13% to 18%) and negative predictive value 96% (95% CI 95% to 98%) for diagnosing hemodynamically significant CAD. With a negative predictive value of 96%, this new acoustic rule-out system could potentially supplement clinical assessment to guide decisions on the need for further diagnostic investigation.

Schmidt et al. (2019) sought to determine the potential of a non-invasive acoustic device (CADScor® System) to reclassify patients with intermediate pre-test probability (PTP) and clinically suspected stable CAD into a low probability group thereby ruling out significant CAD. (5) Audio recordings and clinical data from three studies were collected in a single database. In all studies, patients with a coronary CT angiography indicating CAD were referred to coronary angiography. Audio recordings of heart sounds were processed to construct a CAD-score. PTP was calculated using the updated Diamond-Forrester score and patients were classified according to the current European Society of Cardiology guidelines for stable CAD: low < 15%, intermediate 15-85% and high > 85% PTP. Intermediate PTP patients were re-classified to low probability if the CAD-score was ≤ 20. Of 2245 patients, 212 (9.4%) had significant CAD confirmed by coronary angiography (≥ 50% diameter stenosis). The average CAD-score was higher in patients with significant CAD (38.4 ± 13.9) compared to the remaining patients (25.1 ± 13.8; $p < 0.001$). The reclassification increased the proportion of low PTP patients from 13.6% to 41.8%, reducing the proportion of intermediate PTP patients from 83.4% to 55.2%. Before reclassification 7 (3.1%) low PTP patients had CAD, whereas post-reclassification this number increased to 28 (4.0%) ($p = 0.52$). The net reclassification index was 0.209. Utilization of a low-cost acoustic device in patients with intermediate PTP could potentially reduce the number of patients referred for further testing, without a significant increase in the false negative rate. Reviewers concluded that if these finding can be replicated in prospective studies, the use of the CAD-score could significantly alter the current practice of early rule-out of stable CAD providing important clinical and economic advantages.

Rasmussen et al. (2023) examined whether acoustic detection of coronary stenoses could potentially improve clinical likelihood stratification. (6) Aims were to 1) investigate the

diagnostic performance of an acoustic-based CAD score and 2) study the reclassification potential of a dual likelihood strategy by the ESC-PTP and a CAD score. Consecutive patients (n=1683) with stable angina symptoms referred for coronary CT angiography (CTA) underwent heart sound analyses by an acoustic CAD-score device. All patients with ≥50% luminal stenosis in any coronary segment at coronary CTA were referred to investigation with invasive coronary angiography (ICA) with fractional flow reserve (FFR). A predefined CAD-score cut-off ≤20 was used to rule out obstructive CAD. In total, 439 patients (26%) had ≥50% luminal stenosis on coronary CTA. The subsequent ICA with FFR showed obstructive CAD in 199 patients (11.8%). Using the ≤20 CAD-score cut-off for obstructive CAD rule-out, sensitivity was 85.4% (95% CI 79.7 to 90.0), specificity 40.4% (95% CI 37.9 to 42.9), positive predictive value 16.1% (95% CI 13.9 to 18.5) and negative predictive value 95.4% (95% CI 93.4 to 96.9) in all patients. Applying the cut-off in ESC-PTP 5% to <15% patients, 316 patients (48%) were down-classified to very-low likelihood. The obstructive CAD prevalence was 3.5% in this group. Researchers concluded that in a large contemporary cohort of patients with low CAD likelihood, the additional use of an acoustic rule-out device showed potential to downgrade likelihood and could supplement current strategies for likelihood assessment to avoid unnecessary testing.

Schnaubelt et al. (2022) prospectively used ultra-sensitive phonocardiography via the CADScor® System to measure hemodynamically stable patients with the chief complaint of chest pain during routine waiting times at a high-volume tertiary emergency department (ED). (7) A total of 101 patients were enrolled. Patient workflow was not hindered, and no adverse events were recorded. In 80% of cases, a score was successfully calculated, with 74% at the first, 5% at the second, and 1% at the third attempt. Feasibility was judged as 9.0 (±1.8) by the patients, and 8.9 (±2.6) by the investigators on a 10-point Likert scale. Ultra-sensitive phonocardiography was found to be feasible in acute chest pain patients presenting to a tertiary ED. Thus, the CAD score measured during routine waiting times could potentially serve as an additional tool in a diagnostic pathway for thoracic pain; further research is warranted.

Lehmacher et al. (2023) evaluated the feasibility of the CADScor System for diagnosis of myocardial infarction (MI) in the setting of a large emergency department. (8) Patients presenting to the emergency department with suspected MI were included. Acoustic heart sound analysis was performed in all patients and automated CAD-score values were calculated via a device-embedded algorithm, which also requires inclusion of three clinical variables: age, sex and presence of hypertension. Patients additionally received serial high-sensitive troponin T measurement measurements to assess the final diagnosis according to third Universal Definition of Myocardial Infarction applying the European Society of Cardiology 0 hour/3 hours algorithm. Diagnostic parameters for MI, considering different CAD-score cut-offs, were computed. Of 167 patients, CAD-scores were available in 61.1%. A total of eight patients were diagnosed with MI. At a cut-off value of <20, CAD-score had a negative predictive value (NPV) of 90.7 (78.4–96.3). The corresponding positive predictive value (PPV) was 6.8 (2.7–16.2). For the adjusted CAD-score (age, sex, hypertension), at a cut-off value of <20, NPV was 90.0 (59.6–99.5) with a PPV of 10.8 (5.3–20.6). Researchers concluded that a transcutaneous ultrasensitive microphone for heart sound analysis resulted in a high negative predictive value analogous to the findings in rule-out of stable CAD in elective patients yet was inferior to serial high-

sensitivity cardiac troponin measurements and does not seem feasible for application in an emergency setting for rule-out of MI.

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Neuromodulation Stimulator System (e.g., Portable Neuromodulation Stimulator™)
Effective Date: 05/15/2025
Updates: N/A
Review: N/A

Neuromodulation stimulator system (e.g., Portable Neuromodulation Stimulator™)	A4593, A4594

The Portable Neuromodulation Stimulator™ (PoNS) device is intended to treat chronic balance deficit due to neurologic disorders (e.g., mild-to-moderate traumatic brain injury or multiple sclerosis) in conjunction with physical therapy.

Leonard et al. (2017) studied the effects of noninvasive tongue stimulation using the Portable Neuromodulation Stimulator (PoNS) combined with intensive cognitive and physical rehabilitation on working memory, gait, balance, and concomitant changes in the brain. (1) Fourteen MS patients, seven each in an active and a sham stimulation group, participated.

Participants received intensive physical therapy and working memory training for 14 weeks. Functional magnetic resonance imaging (fMRI) using motor imagery and working-memory tasks were completed prior to and following therapy, as were sensory organization tests (SOT), motor performance measures, and neuropsychological assessment. On the SOT, the active group showed significant improvement from baseline. fMRI revealed significant blood oxygen level-dependent signal changes in the left primary motor cortex for the Active Group, while the sham group had increased activity in bilateral premotor cortices. All individuals improved on working-memory tasks, but only the active group showed increased dorsolateral prefrontal cortex activity. In this cohort of MS patients, the results suggest that PoNS stimulation can enhance motor performance and working memory while also driving neuroplasticity. Further studies are warranted to explore these findings.

Tyler et al. (2019) compared the efficacy of high- and low-frequency noninvasive translingual neurostimulation (TLNS) plus targeted physical therapy (PT) for treating chronic balance and gait deficits due to mild-to-moderate traumatic brain injury (mmTBI). (2) Participants were randomized 1:1 in a 26-week double-blind phase 1/2 study (NCT02158494) with 3 consecutive treatment stages: in-clinic, at-home, and no treatment. Arms were high-frequency pulse (HFP) and low-frequency pulse (LFP) TLNS. Forty-three participants (28 women, 15 men) completed at least 1 stage of the study. Enrollment requirements included an mmTBI ≥1 year prior to screening, balance disorder due to mmTBI, a plateau in recovery with current PT, and a Sensory Organization Test (SOT) score ≥16 points below normal. Participants received TLNS (HFP or LFP) plus PT for a total of 14 weeks (2 in-clinic and 12 at home), twice daily, followed by 12 weeks without treatment. The primary endpoint was change in SOT composite score from baseline to week 14. Secondary variables (e.g., Dynamic Gait Index [DGI], 6-minute walk test [6MWT]) were also collected. Both arms had a significant (P<.0001) improvement in SOT scores from baseline at weeks 2, 5, 14 (primary endpoint), and 26. DGI scores had significant improvement (P<.001-.01) from baseline at the same test points; 6MWT evaluations after 2 weeks were significant. The SOT, DGI, and 6MWT scores did not significantly differ between arms at any test point. There were no treatment-related serious adverse events. Researchers concluded that both the HFP+PT and LFP+PT groups had significantly improved balance scores, and outcomes were sustained for 12 weeks after discontinuing TLNS treatment. Results between arms did not significantly differ from each other. Whether the 2 dosages are equally effective or whether improvements are because of provision of PT cannot be conclusively established at this time.

Ptito et al. (2019) assesses the safety and efficacy of TLNS plus targeted PT in people with a chronic balance deficit after mmTBI. (3) This international, multicenter, randomized study enrolled 122 participants with a chronic balance deficit who had undergone PT following an mmTBI and had plateaued in recovery. Randomized participants received PT plus either high-frequency pulse (HFP; n = 59) or low-frequency pulse (LFP; n = 63) TLNS. The primary efficacy and safety endpoints were the proportion of sensory organization test (SOT) responders (SOT composite score improvement of ≥15 points) and fall frequency after five weeks of treatment, respectively. The proportion of SOT responders was significant in the HFP + PT (71.2%) and LFP + PT (63.5%) groups compared with baseline ($p < 0.0005$). For the pooled population, the SOT

responder rate was 67.2% ($p < 0.00005$), and there were clinically and statistically significant improvements in SOT composite scores after two and five weeks ($p < 0.0005$). Both groups had reductions in falls and headache disability index scores. Mean dynamic gait index scores in both groups also significantly increased from baseline at weeks 2 and 5. Given the outcomes presented here and the lack of improvement in participants in the lengthy period prior to study enrollment, authors speculated that PT enhanced with TLNS contributed to the clinically meaningful benefits in both groups, although the degree of individual contribution of TLNS or PT to the participant remains to be determined in future investigations. Further studies are warranted to assess outcomes with long-term follow-up.

Diep et al. (2021) reviewed the evidence currently available on the portable TLNS device and assessed its potential clinical application. (4) Five randomized controlled trials, three quasi-experimental trials, and seven case reports/series were found. Most studies demonstrated improvements in balance and gait deficits secondary to traumatic brain injury and multiple sclerosis, but evidence is also present to a lesser degree for stroke and balance disorder patients. In these studies, the feasibility and safety of TLNS have been convincingly demonstrated. Functional magnetic resonance studies have also suggested a plausible neuroplastic therapeutic mechanism. However, the efficacy of TLNS remains unclear due to bias and confounding within studies, and heterogeneity of results between studies. Further research to develop an appropriate control group is needed for scientifically valid comparisons of TLNS.

Ho et al. (2022) investigated the effectiveness of TLNS on patients with mmTBI and related brain connectivity using a resting-state functional connectivity (RSFC) approach. (5) Resting-state images with 5-min on GE750 3T scanner were acquired from nine participants with mmTBI. Paired t-test was used for calculating changes in RSFC and behavioral scores before and after the TLNS intervention. The balance and movement performances related to mmTBI were evaluated by Sensory Organization Test (SOT) and Dynamic Gait Index (DGI). Compared to pre-TLNS intervention, significant behavioral changes in SOT and DGI were observed. The analysis revealed increased RSFC between the left postcentral gyrus and left inferior parietal lobule and left Brodmann Area 40, as well as the increased RSFC between the right culmen and right declive, indicating changes due to TLNS treatment. However, there were no correlations between the sensory/somatomotor (or visual or cerebellar) network and SOT/DGI behavioral performance. Although the limited sample size may have led to lack of significant correlations with functional assessments, these results provide preliminary evidence that TLNS in conjunction with physical therapy can induce brain plasticity in TBI patients with balance and movement deficits.

In a 2021 Evidence Analysis, ECRI deemed the evidence for the PoNS device to be “inconclusive-too few data on outcomes of interest”. (6)

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Battery Powered Walker (e.g., Sully Walker)
Effective Date: 05/15/2025
Updates: N/A
Review: N/A

Battery powered walker (e.g., Sully Walker)	E0152

A Sully Walker is a batter-operated walking aid, also known as a “powered walker”, that uses electronic power to assist with forward motion, essentially replacing the need to manually lift and push the walker with each step, typically controlled by a thumb throttle.

Currently, there is a lack of evidence in published peer-reviewed literature to demonstrate the medical benefit of the Sully Walker.

Upper Extremity Rehabilitation System Providing Active Assistance (e.g., IpsiHand™ Upper Extremity Rehabilitation System, Motus Hand, Motus Foot)
Effective Date: 05/15/2025
Updates: N/A
Review: N/A

Upper extremity rehabilitation system providing active assistance (e.g., IpsiHand™ Upper Extremity Rehabilitation System, Motus Hand, Motus Foot)	E0738, E0739

The IpsiHand™ Upper Extremity Rehabilitation System, consisting of an isometric electroencephalogram headset, a powered upper extremity range of motion assist device, and

a microprocessor control unit containing therapy software, allows for delivery of thought-actuated therapy for chronic upper extremity disability in patients with strokes.

The Motus Hand and the Motus Foot are devices comprised of a robotic exoskeleton and a dedicated computer with interactive interface to provide biofeedback on a patient's performance. The Motus devices are for survivors of stroke to use at home or in the clinic, and work to guide patients through therapeutic activities, provide intuitive robotic assistance to augment weakness, and generate personalized statistics.

Humphries et al. (2022) used resting state functional MRI (fMRI) to assess the impact a contralesionally driven electroencephalogram (EEG) brain-computer interface (BCI) therapy had on motor system functional organization. (1) Patients (n=8) used a therapeutic BCI for 12 weeks at home. Resting state fMRI scans and motor function data were acquired before and after the therapy period. Changes in functional connectivity (FC) strength between motor network regions of interest (ROIs) and the topographic extent of FC to specific ROIs were analyzed. Most patients achieved clinically significant improvement. Motor FC strength and topographic extent decreased following BCI therapy. Motor recover correlated with reductions in motor FC strength across the entire motor network. These finding suggest BCI-mediated intervention may reverse pathologic strengthening of dysfunctional network interactions. The study was limited by its non-randomization and its small sample size.

In a 2017 feasibility study, Bundy et al. tested whether a powered exoskeleton driven by a brain-computer interface (BCI), using neural activity from the unaffected cortical hemisphere, could affect motor recovery in chronic hemiparetic stroke survivors. (2) Ten chronic hemiparetic stroke survivors with moderate-to-severe upper-limb motor impairment (mean Action Research Arm Test=13.4) used a powered exoskeleton that opened and closed the affected hand using spectral power from electroencephalographic signals from the unaffected hemisphere associated with imagined hand movements of the paretic limb. Patients used the system at home for 12 weeks. Motor function was evaluated before, during, and after the treatment. Across patients, our BCI-driven approach resulted in a statistically significant average increase of 6.2 points in the Action Research Arm Test. This behavioral improvement significantly correlated with improvements in BCI control. Secondary outcomes of grasp strength, Motricity Index, and the Canadian Occupational Performance Measure also significantly improved. The findings demonstrate the therapeutic potential of a BCI-driven neurorehabilitation approach using the unaffected hemisphere in this uncontrolled sample of chronic stroke survivors. They also demonstrate that BCI-driven neurorehabilitation can be effectively delivered in the home environment, thus increasing the probability of future clinical translation. Several limitations are noted, including but not limited to the following: 1) Because of the home-based setting, it was impossible to ensure that data were free from artifacts; 2) Although the majority of patients had good-quality EEG recordings in the majority of sessions, a few patients met this standard in <50% of sessions; 3) Because the study sample was small in size and was restricted to those with enough motivation to complete the study protocol, the scope and generalizability of the results is uncertain; and 4) The study was uncontrolled.

Jayaraman et al. (2017) reviewed lower-limb technology currently available for people with neurological disorders, such as spinal cord injury, stroke, or other conditions. (3) Three emerging technologies were focused on: treadmill-based training devices, exoskeletons, and other wearable robots. Efficacy of these devices remains unclear, although preliminary data indicate that specific patient populations may benefit from robotic training used with more traditional physical therapy. Use of these devices is limited by insufficient data, cost, and in some cases size of the machine.

Conroy et al. (2019) conducted a single-blind randomized controlled trial of two 12-week robot-assisted interventions; 45 participants were stratified by Fugl-Meyer (FMA) impairment (mean 21 ± 1.36) to 60 minutes of robot therapy (RT; n = 22) or 45 minutes of RT combined with 15 minutes therapist-assisted transition-to-task training (TTT; n = 23). (4) The primary outcome was the mean FMA change at week 12 using a linear mixed-model analysis. A subanalysis included the Wolf Motor Function Test (WMFT) and Stroke Impact Scale (SIS), with significance P <.05. There was no significant 12-week difference in FMA change between groups, and mean FMA gains were 2.87 ± 0.70 and 4.81 ± 0.68 for RT and TTT, respectively. TTT had greater 12-week secondary outcome improvements in the log WMFT (-0.52 ± 0.06 vs -0.18 ± 0.06; *P* = .01) and SIS hand (20.52 ± 2.94 vs 8.27 ± 3.03; *P* = .03). Authors concluded that chronic UE motor deficits are responsive to intensive robot-assisted therapy of 45 or 60 minutes per session duration. The replacement of part of the robotic training with nonrobotic tasks did not reduce treatment effect and may benefit stroke-affected hand use and motor task performance.

Rodgers et al. (2020) sought to determine the clinical effectiveness and cost-effectiveness of robot-assisted training, compared with an enhanced upper limb therapy program and with usual care. (5) Patients with moderate or severe upper limb functional limitation, between 1 week and 5 years following first stroke, were recruited. Interventions included, Robot-assisted training using the Massachusetts Institute of Technology-Manus robotic gym system (InMotion commercial version, Interactive Motion Technologies, Inc., Watertown, MA, USA), an enhanced upper limb therapy programme comprising repetitive functional task practice, and usual care. The primary outcome was upper limb functional recovery 'success' (assessed using the Action Research Arm Test) at 3 months. Secondary outcomes at 3 and 6 months were the Action Research Arm Test results, upper limb impairment (measured using the Fugl-Meyer Assessment), activities of daily living (measured using the Barthel Activities of Daily Living Index), quality of life (measured using the Stroke Impact Scale), resource use costs and quality-adjusted life-years. A total of 770 participants were randomized (robot-assisted training, n = 257; enhanced upper limb therapy, n = 259; usual care, n = 254). Upper limb functional recovery 'success' was achieved in the robot-assisted training [103/232 (44%)], enhanced upper limb therapy [118/234 (50%)] and usual care groups [85/203 (42%)]. These differences were not statistically significant; the adjusted odds ratios were as follows: robot-assisted training versus usual care, 1.2 (98.33% confidence interval 0.7 to 2.0); enhanced upper limb therapy versus usual care, 1.5 (98.33% confidence interval 0.9 to 2.5); and robot-assisted training versus enhanced upper limb therapy, 0.8 (98.33% confidence interval 0.5 to 1.3). The robot-assisted training group had less upper limb impairment (as measured by the Fugl-Meyer Assessment motor subscale) than the usual care group at 3 and 6 months. The enhanced upper limb

therapy group had less upper limb impairment (as measured by the Fugl-Meyer Assessment motor subscale), better mobility (as measured by the Stroke Impact Scale mobility domain) and better performance in activities of daily living (as measured by the Stroke Impact Scale activities of daily living domain) than the usual care group, at 3 months. The robot-assisted training group performed less well in activities of daily living (as measured by the Stroke Impact Scale activities of daily living domain) than the enhanced upper limb therapy group at 3 months. No other differences were clinically important and statistically significant. Participants found the robot-assisted training and the enhanced upper limb therapy group programs acceptable. Neither intervention, as provided in this trial, was cost-effective at current National Institute for Health and Care Excellence willingness-to-pay thresholds for a quality-adjusted life-year. Authors concluded that robot-assisted training did not improve upper limb function compared with usual care. Although robot-assisted training improved upper limb impairment, this did not translate into improvements in other outcomes. Enhanced upper limb therapy resulted in potentially important improvements on upper limb impairment, in performance of activities of daily living, and in mobility. Neither intervention was cost-effective. Further research is needed to find ways to translate the improvements in upper limb impairment seen with robot-assisted training into improvements in upper limb function and activities of daily living. Innovations to make rehabilitation programs more cost-effective are required.

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3. Jayaraman A, Burt S, Rymer WZ. Use of Lower-Limb Robotics to Enhance Practice and Participation in Individuals With Neurological Conditions. Pediatr Phys Ther. Jul 2017; 29 Suppl 3:S48-S56. PMID 28654477
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5. Rodgers H, Bosomworth H, Krebs HI, et al. Robot-assisted training compared with an enhanced upper limb therapy programme and with usual care for upper limb functional limitation after stroke: the RATULS three-group RCT. Health Technol Assess. Oct 2020; 24(54):1-232. PMID 33140719

Summary of Evidence

Based on the literature review for each of these products/services, the evidence is insufficient to determine the effects of the technology on health outcomes.

Coding

Procedure codes on Medical Policy documents are included **only** as a general reference tool for each policy. **They may not be all-inclusive.**

The presence or absence of procedure, service, supply, or device codes in a Medical Policy document has no relevance for determination of benefit coverage for members or reimbursement for providers. **Only the written coverage position in a Medical Policy should be used for such determinations.**

Benefit coverage determinations based on written Medical Policy coverage positions must include review of the member's benefit contract or Summary Plan Description (SPD) for defined coverage vs. non-coverage, benefit exclusions, and benefit limitations such as dollar or duration caps.

CPT Codes	92972, 0615T, 0620T, 0621T; 0622T, 0623T; 0624T; 0625T; 0626T, 0631T, 0639T, 0640T; 0643T, 0645T, 0716T, 0744T, 0748T, 0764T, 0765T, 0770T, 0771T, 0772T, 0773T, 0774T, 0777T, 0778T, 0791T, 0807T, 0808T, 0859T
HCPCS Codes	A4468, A4593, A4594, C1052, C1761, C9764; C9765; C9766; C9767; C9772, C9773, C9774, C9775, C9777, C9786, E0152, E0738, E0739, E1905

*Current Procedural Terminology (CPT®) ©2024 American Medical Association: Chicago, IL.

References

References are included in the Rationale following each procedure/service.

Centers for Medicare and Medicaid Services (CMS)

The information contained in this section is for informational purposes only. HCSC makes no representation as to the accuracy of this information. It is not to be used for claims adjudication for HCSC Plans.

The Centers for Medicare and Medicaid Services (CMS) does not have a national Medicare coverage position. Coverage may be subject to local carrier discretion.

A national coverage position for Medicare may have been developed since this medical policy document was written. See Medicare's National Coverage at <https://www.cms.hhs.gov>.

Policy History/Revision

Date	Description of Change
05/15/2025	Document updated with literature review. (See Rationale for effective, update and review dates for each individual procedure/service.) The following procedure/service was moved to another medical policy: • Gastrointestinal myoelectrical activity study to MED201.017 Gastrointestinal (GI) Motility Measurement.
08/15/2023	Document updated. The following procedure/service was moved to another medical policy: Transcatheter tricuspid valve implantation/replacement to SUR707.032 Transcatheter Tricuspid Valve Procedures.

07/01/2023	Document updated. (See Rationale for effective, update and review dates for each individual procedure/service.) The following procedures/services were moved to other medical policies: • Therapeutic IntraVascular UltraSound (TIVUS™) to SUR707.031 Pulmonary Artery Denervation; • Non-pneumatic compression garment/controller (e.g., Dayspring™ system) to MED202.060 Pneumatic Compression Pumps for Treatment of Lymphedema and Venous Ulcers; • External Upper Limb Tremor Stimulator of the Wrist to MED201.040 Transcutaneous Electrical Stimulation (TENS) and Transcutaneous electrical Modulation Pain Reprocessing (TEMPR); • Viable Allograft Supplemental Disc Regeneration (VAST) to SUR705.049 Allograft Injection for Degenerative Disc Disease.
06/15/2023	Document updated. (See Rationale for effective, update and review dates for each individual procedure/service.)
01/15/2023	Document updated. (See Rationale for effective, update, and review dates for each individual procedure/service.)
10/01/2021	Document updated. (See Rationale for effective, update, and review dates for each individual procedure/service.)
08/15/2021	Document updated. (See Rationale for effective, update, and review dates for each individual procedure/service.)
07/01/2021	Document updated. (See Rationale for effective, update, and review dates for each individual procedure/service.)
05/15/2021	Document updated. (See Rationale for effective, update, and review dates for each individual procedure/service.)
01/01/2021	New medical document. The list of procedures/services are considered experimental, investigational and/or unproven as they have not received approval from the U.S. Food and Drug Administration (FDA) and/or there is little to no evidence to prove efficacy.