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Welcome to the November issue with updates on some interesting technology. Anyone who’s been paying attention knows how fast things can change, so if you’re reading this later, we hope you’ll take these as starting points, check out the references, and contact the authors and search the literature for the latest.

Some of the things we wanted to let you know about that didn’t make it into the issue include possibly-familiar technology used in new ways.

- Many nurse life care planners are familiar with cochlear implants, especially in profoundly deaf children. You might be less familiar with the increasing applications for elders with hearing loss later in life. Here’s Bruce Sloane, an 80-something with some powerful information.

  I’m hearing sounds I haven’t heard for decades: my wife’s soft whispers, birds singing and twittering, leaves blowing, soft TV, and telephone calls. I detailed my experiences on a blog on American Cochlear Implant Alliance website, starting as I slowly watched my hearing deteriorate year by year and started recording events as I stumbled toward getting a cochlear implant. (Sloane, 2018)

- We’re working on a future issue on updates in amputation care in May 2020. Meanwhile, here’s the link to a great story of a young man with congenital arm absence who made himself a functional prosthetic arm and hand. Spoiler alert: In the video he says the day he wore it to school for the first time was the first time in his life he liked having people stare at him. See for yourself at https://www.youtube.com/watch?v=VymKjQwodY

- Three-dimensional (3-D) printing technology has gotten so inexpensive that it’s reached into the community, with Scout troops and other volunteers making hands for kids for as little as a few dollars. See enablingthefuture.org for more. You can also find a study report on research into how this technology is working in children who have lost an arm or hand (Zuniga et al., 2016).

- Other uses for 3D printing are found in orthopedics. In 2013 came this report, at https://www.healio.com/orthopedics: “(S)urgeons are already using 3-D printing to create plastic models for difficult-to-visualize fractures and deformities. At the American Academy of Orthopaedic Surgeons Annual Meeting, a group at the Medical College of Wisconsin lead by Rick Papendrea, MD, presented a cheap and efficient way to fabricate plastic models of scapula and distal humeri for complex shoulder and elbow problems using 3-D printing.”

- Surgical teams use 3D models built from imaging to plan complex repairs for congenital heart defects (Batteux, 2019), liver surgery (Perica and Sun, 2017), complex thoracic surgery (Mayo Clinic, nd), neurosurgery, (Balzer and Scott, 2015), and intracranial and craniofacial defects (Verweij, 2016), among others.

- There are now ways to use living biological tissues in 3D printing. The potential for developing organs and structures for transplant without concern for rejection, such as lungs, kidneys, and hearts, is in active development. (Wadsworth, 2016; Dvir, 2019) (There are also implications for replacing animal products like leather.)

I could go on— I come from a family of engineers so I really like this kind of thing— but I’ll leave it to you to check these out. Think of ways we could integrate these opportunities into our life care plans, now and in the future. Right now, we’d like to hear from you if you have already had experience with any of these technologies in your practices. What happened? What would you like to see? Stay in touch.

References
Mayo Clinic (nd) 3D printing of patients’ anatomy aids in surgical planning https://www.youtube.com/watch?v=MxSaPa7qmd Retrieved 10/2/2019

From the Editor

Wendie A. Howland
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Information for Authors

AANLCP® invites interested nurses and allied professionals to submit article queries or manuscripts that educate and inform the Nurse Life Care Planner about current clinical practice methods, professional development, and the promotion of Nurse Life Care Planning within the medical-legal community. Submitted material must be original. Manuscripts and queries may be addressed to the Editorial Committee. Authors should use the following guidelines for articles to be considered for publication. Please note capitalization of Nurse Life Care Plan, Planning, etc.

Text

Manuscript length: 1500 – 3000 words

- Use Word® format (.doc, .docx) or Pages (.pages)
- Submit only original manuscript not under consideration by other publications
- Put the title and page number in a header on each page (using the Header feature in Word)
- Use Times New Roman, Arial, or Calibri 12 point font
- Place author name, contact information, and article title on a separate title page, so author
- Name can be blinded for editorial review
- Use APA style (Publication Manual of the American Psychological Assoc. 6th Ed)

Art, Figures, Links

All photos, figures, and artwork should be in JPG or PDF format (JPG preferred for photos). Line art should have a minimum resolution of 1000 dpi, halftone art (photos) a minimum of 300 dpi, and combination art (line/ tone) a minimum of 500 dpi.

Each table, figure, photo, or art should be on a separate page, labeled to match its reference in text, with credits if needed (e.g., Table 1, Common nursing diagnoses in SCI; Figure 3, Time to endpoints by intervention, American Cancer Society, 2003) Live links are encouraged. Please include the full URL for each.

Editing and Permissions

The author must accompany the submission with written release from:
- Any recognizable identified facility for the use of name or image
- Any recognizable person in a photograph, for unrestricted use of the image
- Any copyright holder, for copyrighted materials including illustrations, photographs, tables, etc.

All authors must disclose any relationship with facilities, institutions, organizations, or companies mentioned in their work. All accepted manuscripts are subject to editing, which may involve only minor changes of grammar, punctuation, paragraphing, etc. However, some editing may involve condensing or restructuring the narrative. Authors will be notified of extensive editing. Authors will approve the final revision for submission. The author, not the Journal, is responsible for the views and conclusions of a published manuscript. Submit your article as an email attachment, with document title articlename.doc, e.g., wheelchairs.doc

All manuscripts published become the property of the Journal. Manuscripts not published will be returned to the author. Queries may be addressed to the care of the Editor at: journal@aanlcp.org

Manuscript Review Process

Submitted articles are peer reviewed by Nurse Life Care Planners with diverse backgrounds in life care planning, case management, rehabilitation, and the nursing profession. Acceptance is based on manuscript content, originality, suitability for the intended audience, relevance to Nurse Life Care Planning, and quality of the submitted material. If you would like to review articles for this journal, please contact the Editor.

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A Message from the President

The executive board and the management company are excited that the new AANLCP website will be up and running by the end of September. We would like to thank Colin Parker and Lonestar Sales Performance for working quickly and efficiently to get the new site up and running!

We’re looking to automate the AANLCP’s systems and move to a paperless system. We’re still in the process of cleaning up from the previous years; our new website will give us the opportunity to start fresh and organized. When it launches:

• Our management company will enjoy more up-to-date tools for resources, emails, recruitment, follow-ups, renewals, and marketing. In turn, this will free up their time to focus on important items like membership and sponsorship.

• We will launch the revised mentorship program. If you have considered becoming a mentor now is your chance!

• We will display names and photos of members who have won our annual awards, so if you have previously won an award get your picture ready.

• We will also list all who have served on the executive board. Debra will be sending out an email requesting your picture and the date(s) you served.

• We will have a few new membership perks that will be hitting the membership benefit section of the website. Check out your new benefits!

Becky Czarnik and the Education Committee continue to work hard to bring you the monthly webinars. They are working with Colin to update the Crash Cart for the new website. If you have any resources for the Crash Cart you would like to share or suggestions for webinars please contact Becky, becky@sierranurse.com.

Kelly Campbell, Jenn Craigmyle, and the 2020 Conference Committee are working hard to bring you an excellent conference in sunny San Diego. Early-bird registration will open soon. Mark your calendars and save the date, March 6-8, 2020!

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AANLCP President August 2018 - December 2019
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Contributors to this Issue

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Research engineer skilled in machine learning, big-data analysis, signal processing, software development, math modeling, control theory, and technical communication, with exceptional ability to blend and apply concepts across diverse technical fields.

NATHAN COPELAND  
Nathan Copeland was 18 years old when a car accident caused his quadriplegia in 2004. This catastrophic event often left him feeling like he would no longer be able to accomplish much with his life. Years later when presented the opportunity to help shape future technologies that could eventually benefit people in similar situations, he couldn’t refuse. For the last 5 years Nathan has participated in a brain-computer interface study through the University of Pittsburgh. Using microelectrode arrays implanted in his motor and sensory cortices he is able to control a robotic arm and receive sensations back from it. Nathan was the first human to have arrays implanted in his sensory cortex.

While his time with the research study will come to an end, Nathan has built up a wealth of experience that will stick with him for the rest of his life, from meeting President Obama to giving presentations in Japan. He hopes to continue sharing his story and insights into using an implanted BCI with anyone that would find them valuable.

KIMBERLY GULLY,  
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has been the Executive Director for Rehab Without Walls in Southern CA for over 17 years. She lectures locally, regionally and nationally on brain injury, patient advocacy, and healthcare technology. She is President of the Medical Speech Language Pathology Council of California and past Board Member for the BIA-California and the CA Speech & Hearing Association. She has been a Certified Brain Injury Specialist Trainer through the Academy of Certified Brain Injury Specialists (ACBIS) since 2009 and also runs the continuing education training program for the Rehab Without Walls division. She can be reached at kimberlygully@rehabwithoutwalls.com

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Nellie Kreimer has been a registered nurse since 1985. Ms. Kreimer is passionate about improving health and quality of life for those in need through advancement of nurse life care planning profession. Ms. Kreimer’s interests include neuroscience nursing, traumatic and acquired brain injury, and spinal cord injury. Ms. Kreimer can be contacted at nelliekreimer@gmail.com

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Kristin Quick, PhD, is a Neurotechnology Scientist in the Department of Physical Medicine and Rehabilitation at the University of Pittsburgh. She completed her doctoral studies in Bioengineering at University of Pittsburgh in 2015. Her PhD work focused on improving brain-computer interfaces through understanding the underlying neural manifold of motor cortex as well as investigating methods to assess sensorimotor performance.

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CALL FOR ABSTRACTS FOR POSTER PRESENTATIONS
2020 AANLCP Education Conference

Creatively display your information to benefit our collective knowledge! If you have a specialty or special interest, we would all benefit from knowing more about it. The top poster presentation will be featured in an upcoming issue of the AANLCP journal!

Apply: Our primary topics of interest are traumatic brain injury, spinal cord injury and practice management for life care planners, but others will be considered. Display space is limited. Send in your idea (abstract) to Amy@MacKenzieclcp.com by December 15, 2019, and we will notify you if it's accepted.

Poster guidelines: You will have a 4’ x 4’ area to display your poster. Nothing can extend beyond that perimeter. Consider that attendees will be looking your poster from a distance of 5 feet or more. Your poster's main message should be self-explanatory so that you are free to supplement and discuss particular points raised by viewer; QR codes are encouraged to link to the full work including detailed methods and tables. We will publish the QR codes for all posters in the Journal and in the conference proceedings. The excellent YouTube video below will help you make your poster rewarding for presenter and viewer alike.

How to create a better research poster in less time (including templates and an easy link on how to do QR codes)
https://www.youtube.com/watch?v=1RwJbhkCA58

Why traditional academic posters are bad for presenters and readers 0:00-11:35

** What is a good design? 11:35-12:08

** The redesign! 12:08-16:14

** Examples! 16:14-17:28

https://www.americannursetoday.com/how-to-create-an-effective-poster-presentation/

In the linked paper, the sequence of any illustrations should be indicated with numbers or letters, preferably in a bold san serif font. Any figure or table should have a heading of one or two lines stating the point of its message. Detailed information can be provided in a brief legend in small type below the figure.
WHAT'S IN YOUR iPAD?
APPS FOR YOUR BRAIN

Kimberly Gully, MS, CCC, CCM, CBIST

Over the past decade digital media has infiltrated every part of our day to day life with significant effect on information sharing in all industries including healthcare. Our patients, clients, families, and colleagues have information overload and need simplicity and direction to filter out the visual noise.

While useful for anyone, including our readers and their children or grandchildren, these free or low-cost functional resources apps address many areas that individuals with post-TBI impairments often find problematic. The market is flooded with more-expensive apps with a greater clinical focus, but they may not hold an individual’s interest or feel too much like traditional therapy. While there are drawbacks to using free or low-cost apps not developed by professionals, e.g., annoying ads or limited scope, benefits outweigh annoyances if you are looking for engaging and affordable tools.

Another advantage is that if you get tired of one app and decide you want to try another, there are many free or affordable choices. Others, such as Lumosity, may be too complex or overwhelming for some individuals, starting with the need to remember an account sign-in.

Precursors and Contributors to Memory
Many times, we leap directly to working on memory deficits without addressing critical underlying attention challenges. Someone who cannot attend to a spoken word, written information, or events has a very diminished likelihood of being able to properly store and retrieve that information.

Categorization helps us remember something by attaching it to like memories by features like location, size, color, smell, or evoked emotion, among others. Categorizing is impaired after brain injury, especially when there is a need to use abstract reasoning or association. For further information about the relationship between attention and memory please refer to the references listed below.

These apps have been selected due to their simplicity, intuitiveness, and intrigue to engage factors – see Table 1. Some considerations for apps to use with brain injured individuals includes evaluating the app for ease of use, clarity of graphics, and simple non-cluttered visual field. Other items that are nice to have include variety of levels available and timed activities or some way of showing
Use these apps to work on improving skills associated with attention:

- Chain of Thought
- AB Math Expert
- 10 Pin Shuffle Bowling
- Schulte Table
- Catch a Color

Use these apps to work on improving skills associated with visual processing:

- CMKY
- Digital Finger Tapping Test
- The Impossible letter Game
- 7 Sevens

Use these apps to work on improving skills associated with visual processing:

- Math Splat
- Cubistry
- Kakooma
- Matrix
- Greg

Use these apps to work on improving skills associated with visual processing:

- IQ2
- What’s the Difference
- Fairway Solitaire
- Hidden Objects Crosswords
- Fast Cards

Use these apps to work on improving skills associated with visual processing:

- Speech, Cognition & Communication

Use these apps to work on improving skills associated with visual processing:

- Alphabet Letter Confidence
- Number Link
- The Guesstimate Game
- Brain Games
- Sight Words

Use these apps to work on improving skills associated with visual processing:

- Verbal
- Verbally

Use these apps to work on improving skills associated with eye-hand coordination:

- Eye Hand Coordination

Use these apps to work on improving skills associated with eye-hand coordination:

- Cut The Buttons
- Falldown
- Flick Golf
- Color Tap Plus
- Frisbee Forever

Use these apps to work on improving skills associated with eye-hand coordination:

- Finger on the Line
- Aerox
- Fruit Ninja
- Sky Burger
- Flick Kick

Use these apps to work on improving skills associated with eye-hand coordination:

- Activities of Daily Living

Use these apps to find more free or low cost apps for your brain and tips on how to use the iPad:

- Apps About APPS & Other Cool Stuff

For more information about APPS or to sign up for APPy Hour email list contact:

Kimberly Gully, Executive Director
kimberlygully@rehabwithoutwalls.com

To find out more information about Rehab Without Walls contact us at 866.734.2296 or visit us at www.rehabwithoutwalls.com
Introduction

Smart phones and tablets are very popular devices and are being utilized in many brain injury programs. Patients and families look to the therapy team to recommend appropriate apps to use with their loved ones. While the number of affordable apps developed specifically for individuals with cognitive and language challenges is limited, there are many low cost and/or free programs available.

Objective

To provide a variety of apps for suitable to use for all age individuals with cognitive and language issues. Not all apps are appropriate for all individuals.

Tips on selecting and using apps:
• Look for visual appeal – simple/uncluttered screen
• Does the app have tracking capabilities?
• Does the app have progressive levels?
• Does the app come in a Lite version?*
• Identify the target activity in the app - many focus on more than one area
• Look at the app’s features to see if you can use some part of it to accomplish what you need
• Apps do not take the place of a therapist
• Apps are fun and help people engage more

Stress Reduction

Use these apps to work on improving skills associated with reducing stress.

Memory

Use these apps to work on improving skills associated with memory.

Problem Solving/Logic

Use these apps to work on improving skills associated with problem solving.

Language

Use these apps to work on improving skills associated with language.

Organization

Use these apps to work on improving skills associated with organization.
Table 1 – App is free unless otherwise indicated. Click on link to go to app.

<table>
<thead>
<tr>
<th>App</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerox</td>
<td>Working with this visually appealing, yet simple app, will assist you with eye hand coordination, visual scanning, problem solving, speed of response, visual-spatial concepts and will keep you engaged and wanting to practice getting to the next level. It starts out easy and gradually becomes more difficult. Allows you to go back to an easier level if needed. <a href="https://itunes.apple.com/us/app/aerox/id370532221?mt=8">https://itunes.apple.com/us/app/aerox/id370532221?mt=8</a></td>
</tr>
<tr>
<td>Apps Gone Free</td>
<td>Get high quality apps for FREE! This app provides daily apps that are free for a short period of time. This allows you to scan apps to see if they are something that might be of interest, download and try it for free. If you decide it is not for you, you can delete it and it did not cost you anything! Many of the apps on my iPad came from here for FREE!!! <a href="https://appsto.re/us/CEJdC.i">https://appsto.re/us/CEJdC.i</a></td>
</tr>
<tr>
<td>Can You Match?</td>
<td>Practices using your visual memory, attention and visual scanning. It is like a traditional memory game, however the twist to this one is that the rows move around. You must pay close attention and use your visual scanning skills and memory to recall where the cards go as they move around the board. The better you are at the game the more difficult it becomes. It includes options to continue to go back to the easier levels if needed. <a href="https://itunes.apple.com/us/app/can-you-match/id514730264?mt=8&amp;ls=1">https://itunes.apple.com/us/app/can-you-match/id514730264?mt=8&amp;ls=1</a></td>
</tr>
<tr>
<td>CMYK</td>
<td>Use this app to improve your eye hand coordination, speed of response, visual scanning, direction following, impulse control and initiation. Different color lines appear from the top of the screen. There are corresponding buttons at the bottom of the screen to press to match the colors. When you see a white line you are to swipe the buttons to release a white dot to erase the line. <a href="https://itunes.apple.com/be/app/cmyk/id1124547330">https://itunes.apple.com/be/app/cmyk/id1124547330</a></td>
</tr>
<tr>
<td>Collect – Photo Journal, Diary</td>
<td>One of my favorite memory journals. This app allows you to document in pictures!!! Perfect for those individuals who are very visual, are not yet able to write, or need to see and to write what they did. Another great feature is that it allows you to use tags in order to quickly find journal entries that are related. Getting in the mode of documenting with pictures and writing has been used in rehab setting for many years. This allows you to do it on your phone or on your tablet. <a href="https://appsto.re/us/uIbMI.i">https://appsto.re/us/uIbMI.i</a></td>
</tr>
<tr>
<td>Color Tap Plus</td>
<td>This app helps work on divided attention, motor skills, visual scanning, matching and memory. Tap the dots that match the color of the bar at the top of the screen. Watch the top of the screen as the color changes frequently. <a href="https://appsto.re/us/uIbMI.i">https://appsto.re/us/uIbMI.i</a></td>
</tr>
<tr>
<td>Guestimate</td>
<td>So you want to work on your visual perception, problem solving and reasoning? This app will challenge your estimation abilities. For example it will present a circle with a dot on the outside of the circle. Your job is to place the dot in the center of the circle. My favorite thing about this app is that it gives you immediate feedback about your accuracy before it moves you to the next level. My second favorite thing about this app is that it has simple and complex problems for you to solve. <a href="https://appsto.re/us/4J2Z-i">https://appsto.re/us/4J2Z-i</a></td>
</tr>
<tr>
<td>Greg</td>
<td>Use this app to work on divergent attention, visual scanning, short term memory, abstract reasoning, logic, planning, and problem solving. Who knew an app could combine using colors and numbers! Four different levels of difficulty allow for warming up to the concept of the game and practice before you actually go to the more difficult levels. <a href="https://appsto.re/us/107y1.i">https://appsto.re/us/107y1.i</a></td>
</tr>
<tr>
<td>Impossible Letter Game</td>
<td>The concept can be both very simple and very complex. Your job is to find the mismatched letter in a field of letters that are all the same except one! Once you locate that letter and touch it a new set of letters appear and you start all over again! Great to work on visual scanning and visual discrimination. This one can play tricks on your eyes. <a href="https://appsto.re/us/-_SVY.i">https://appsto.re/us/-_SVY.i</a></td>
</tr>
<tr>
<td>Kakooma</td>
<td>This simple concept of scanning numbers to determine which 2 numbers combined via addition, subtraction or multiplication result in one of the other numbers in that grouping. Covers a wide variety of skills: frustration tolerance, sustained attention, memory, abstract thinking, visualization, visual scanning, and math skills to name a few. <a href="https://itunes.apple.com/us/app/kakooma/id978423277?mt=8">https://itunes.apple.com/us/app/kakooma/id978423277?mt=8</a></td>
</tr>
<tr>
<td>K12 Money</td>
<td>This app lets you practice identifying and solving math problems with money. Count, match, and make change with U.S. coins up to quarters and bills up to $20. There are various categories including counting money, show me the money, making change, matching amounts, and show values. This app allows you to work at your own pace, check your answers and does not require real money to practice these skills <a href="https://appsto.re/us/Vrfyz.i">https://appsto.re/us/Vrfyz.i</a></td>
</tr>
<tr>
<td>Schulte Table</td>
<td>This a great app to improve your visual scanning, attention, sequencing, and speed of response. Items in the form of numbers or letters are presented to you in a 4 x 4, 5 x 5 or 6 x 6 square. You must touch the items in sequence until you reach the final item. You may select whether you are sequencing numbers or letters <a href="https://appsto.re/us/6Y4ed.i">https://appsto.re/us/6Y4ed.i</a></td>
</tr>
<tr>
<td>(Learn English) Sentence Master</td>
<td>Focus is on the sequencing of words to form a sentence to enhance skills like word recognition, sequencing, and reading comprehension. There are five different levels including beginner, competent, professional expert and proverb. This app was originally designed for learning English, However, it is the perfect tool for disrupted language skills. <a href="https://itunes.apple.com/us/app/sentence-builder-master/id98024043">https://itunes.apple.com/us/app/sentence-builder-master/id98024043</a></td>
</tr>
<tr>
<td>Word Mess</td>
<td>Find words in beautifully designed word clouds. Improve your vocabulary and visual scanning ability! It encourages word recognition and general knowledge. Word Mess has four different modes. Find Mode - simple word finding, boosts visual scanning; Rhymes - find words that rhyme together; Categories - boost your general knowledge with endless combinations of hundreds of categories! Bonus Round - Odd one out – you must determine which one does not fit with the others. <a href="https://itunes.apple.com/us/app/word-mess/id504739597?mt=8">https://itunes.apple.com/us/app/word-mess/id504739597?mt=8</a></td>
</tr>
</tbody>
</table>

Disclaimer - As technology improves apps that were previously functional no longer work on newer devices. Like any other skill or resource, it is important to stay on top of new apps that are available and which ones no longer work on your device. Not all apps are appropriate for all people.
improved ability. Hypersensitivity to light or sound are contraindications for using tablets, smart phones, or some apps. While volume can be turned down and brightness adjusted, it may still have a negative impact on individuals who are easily overstimulated. When in doubt consult with the physician for any limitations or concerns.

It is time-consuming to search for apps to use with different individuals and new apps are added every day. For more ideas go to: [http://bit.ly/RWWAPPyHour](http://bit.ly/RWWAPPyHour) If you have a specific request and want suggestions, feel free to email me at kimberlygully@rehabwithoutwalls.com

### References

Grow your career with FIG!

Life Care Planning
Medical Cost Projections
Medicare Set-Asides

Plant A Seed...
Certification Classes
Online & onsite
Pre-approved for certification (CNLCP, CLCP, MSCC)
Payment plan

Nourish Your Foundation...
Customized Coaching

Strengthen Your Roots...
Continuing Education
Pre-approved for CNLCP, CLCP, MSCC & RN

Retreat Of Resources...
Treehouse
Interactive website with resources, happenings, & networking

FIG
FIGeducation.com
TECHNOLOGY FOR TINNITUS

Nellie Kreimer MSHCA, BSN, CNLCP, CLCP, LNC

Introduction

Hearing is essential for speech and language development, comprehension, memory, learning, and social development and integration. Tinnitus, most commonly known as ringing in the ear(s), is an otolaryngological impairment that interferes with auditory cognitive functions, including concentration, comprehension, reasoning, problem solving, memory, attention, and communication (Gudwani et al., 2017). In the United States, 50 million adults (approximately 25% of population) are affected by tinnitus (Theodoroff et al., 2019). Out of the 50 million affected by tinnitus, 10 million (approximately 20%) report severe impairment in quality of life including but not limited to sleep disorder, anxiety, and depression (Wurzer et al., 2018; Adamchic et al., 2013; Theodoroff et al., 2017). Interestingly, 80% of individuals with tinnitus have sensorineural hearing loss, although not all individuals with hearing loss experience tinnitus (Hullfish et al., 2019).

Repetitive, loud noise exposure, aging, ototoxic medications, high blood pressure, heart disease, thyroid disease, fibromyalgia, chronic pain, head and neck trauma, auditory, vestibular, and facial nerve tumors are common causes (American Tinnitus Association, ATA, 2017; Theodoroff et al., 2017). Significantly, tinnitus associated with traumatic brain injury is resistant to treatment because of heightened auditory signaling and hyperexcitability of the sound processing brain structures (Ortiz, 2016). It is one of the major work-related disabilities affecting musicians, manufacturing and construction workers, first responders, pilots, flight attendants, and military personnel (ATA, 2017). It is seen in 32.3% of 224,610 veterans receiving healthcare services (Martz et al., 2018).

To date, there is no known cure. Evidence-based treatment such as cognitive behavioral therapy (CBT) focus on acceptance and adaptation, while hearing aids with tinnitus maskers and sound generators only mask sound while in use (Swain et al., 2016). Noninvasive neuromodulation and neuroplasticity-based hearing threshold adapted coordinated reset (HTA-CR) therapy provides longer lasting relief. Clinical studies demonstrate that it has positive outcomes in minimizing distress, co-morbidities, loudness and persistence (Wurzer et al., 2017; Theodoroff et al., 2017).

Tinnitus pathophysiology: It’s all in the head

Subjective tinnitus (ICD-10-CM H93.19), often referred to as phantom sound, is perception of sound without a corresponding physical sound source. It is common, and can only be heard by an individual who experiences it. This either can occur in one or both ears as ringing, hissing, chirping, crickets, whooshing, whistling, and roaring (National Organization for Rare Diseases, NORD, 2017; American Tinnitus Association, ATA). Objective or pulsatile tinnitus is rare, is caused by pathological vascular anomalies, and can be heard by the individual and the examiner.

Although considered an otolaryngological condition of the peripheral auditory system, tinnitus is generated in areas in the brain, including the cerebral auditory cortex, brain stem, amygdala, cingulate cortex, and parahippocampus (Swain et al., 2015; Theodoroff et al., 2017; Adamchic et al., 2013). Decreased sound transmission decreases inhibitory neuron function. This causes hyperactivity and maladaptive

NURSING DIAGNOSES TO CONSIDER

NANDA-I 2017-2018

1. Ineffective health maintenance.
   Domain 1, Health Promotion; Class 2, Health management
2. Deficient diversional activity.
   Domain 1, Health Promotion; Class 1, Health awareness
3. Disturbed sleep pattern.
   Domain 4, Activity/Rest; Class 1, Sleep/rest
4. Fatigue.
   Domain 4, Activity/Rest; Class 3, Energy balance
5. Impaired memory.
   Domain 5, Perception/Cognition; Class 4, Cognition
6. Ineffective coping.
   Domain 9, Coping/stress tolerance; Class 2, Coping responses
7. Anxiety.
   Domain 9, Coping/stress tolerance; Class 2, Coping responses

KEY WORDS:
   audiology, brain injury, neurological disorders, neuromodulation, neuroplasticity, technology, tinnitus
TINNITUS FUNCTIONAL INDEX

Today's Date ____________________ Your Name ____________________ Please Print ____________________

Month / Day / Year

Please read each question below carefully. To answer a question, select ONE of the numbers that is listed for that question, and draw a CIRCLE around it like this: 10% or 1.

I Over the PAST WEEK...

1. What percentage of your time awake were you consciously AWARE OF your tinnitus?
   Never aware ► 0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% ◄ Always aware

2. How STRONG or LOUD was your tinnitus?
   Not at all strong or loud ► 0 1 2 3 4 5 6 7 8 9 10 ◄ Extremely strong or loud

3. What percentage of your time awake were you ANNOYED by your tinnitus?
   None of the time ► 0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% ◄ All of the time

SC Over the PAST WEEK...

4. Did you feel IN CONTROL in regard to your tinnitus?
   Very much in control ► 0 1 2 3 4 5 6 7 8 9 10 ◄ Never in control

5. How easy was it for you to COPE with your tinnitus?
   Very easy to cope ► 0 1 2 3 4 5 6 7 8 9 10 ◄ Impossible to cope

6. How easy was it for you to IGNORE your tinnitus?
   Very easy to ignore ► 0 1 2 3 4 5 6 7 8 9 10 ◄ Impossible to ignore

C Over the PAST WEEK...

7. Your ability to CONCENTRATE?
   Did not interfere ► 0 1 2 3 4 5 6 7 8 9 10 ◄ Completely interfered

8. Your ability to THINK CLEARLY?
   Did not interfere ► 0 1 2 3 4 5 6 7 8 9 10 ◄ Completely interfered

9. Your ability to FOCUS ATTENTION on other things besides your tinnitus?
   Did not interfere ► 0 1 2 3 4 5 6 7 8 9 10 ◄ Completely interfered

SL Over the PAST WEEK...

10. How often did your tinnitus make it difficult to FALL ASLEEP or STAY ASLEEP?
    Never had difficulty ► 0 1 2 3 4 5 6 7 8 9 10 ◄ Always had difficulty

11. How often did your tinnitus cause you difficulty in getting AS MUCH SLEEP as you needed?
    Never had difficulty ► 0 1 2 3 4 5 6 7 8 9 10 ◄ Always had difficulty

12. How much of the time did your tinnitus keep you from SLEEPING as DEEPLY or as PEACEFULLY as you would have liked?
    None of the time ► 0 1 2 3 4 5 6 7 8 9 10 ◄ All of the time

Copyright Oregon Health & Science University 2008

08.15.08

Figure 1. Tinnitus Functional Index instrument. ©Oregon Health and Science University, 2008
colonization of excitatory neurons in the central auditory pathway (Sedley et al., 2015; Wurzer et al., 2018). Their uncontrolled, rapid firing impedes the brain's ability to accurately process electrical sound impulses, and in turn orchestrates the “tinnitus symphony” (Sedley et al., 2015; Swain et al., 2015).

Innovative tinnitus therapy—Hearing threshold adapted-coordinated reset (HTA-CR)

The American Tinnitus Association (ATA) and the American Audiology Association recommend initial evaluation to rule out medical causes before treatment. The Veterans Administration (VA) Rehabilitation Research and Development Service, National Center for Rehabilitative Auditory Research (NCRAR) recommends an individualized treatment plan for auditory and non-auditory factors. This may include, but not be limited to: cognitive behavioral therapy (CBT), sound therapy, neuromodulation sound therapy, and hearing aids with tinnitus maskers (Theodoroff et al., 2019; AAA, 2019; ATA, 2017). However, most of these provide only short-term relief.

HTA-CR

Developed by the Hearing Research Center in Germany, HTA-CR is based on neuromodulation and neuroplasticity (Wurzer et al., 2018). Neuromodulation (NM) means using individualized, repetitive, low-amplitude, sequenced sounds to decrease excitatory activity and increase inhibitory activity to restore central auditory pathway balance. Neuroplasticity is neurons’ ability to form new connections. Persistent NM stimulation promotes alternate neural connections that train the brain to ignore the tinnitus sound over time (Hauptmann et al., 2015; Wurzer et al., 2018).

Clinical trials utilizing HTA-CR have shown positive outcomes and may result in longer-lasting and possibly permanent relief. A clinical trial on 500 patients demonstrated 60-75% improvement in symptoms on tinnitus questionnaire scores (Figure 1), while approximately 30% of patients reported no change from baseline (Wurzer et al., 2018). Another clinical trial by Wurzer et al., 2018 on 25 patients with chronic tinnitus demonstrated a 72% positive outcome with relief, no response to treatment in 20%, and worsening symptoms in 2%.

Desyncra: Hearing threshold adapted coordinated reset (HTA-CR)

Indications Desyncra for Tinnitus Therapy System (Figure 2) is a Class IIa FDA-certified (2016) medical device (K151558) for HTA-CR neuromodulation (DME billing code E1399) for use by adults over 18 years of age. The system includes an iPod, software, and customized earbuds. It can only be purchased, fitted, and adjusted by a licensed, trained professional, such as an audiologist. The cost ranges between $3,500-$7000, depending on the provider and location.

The four acoustic stimulation sounds are based on the individual's tinnitus frequency and reprogrammed based on response to treatment (Haller et al., 2017). This requires 5 visits: two initial programming sessions two weeks apart, and followup programming sessions at 1, 3, and 6 months.

Figure 2 Desyncra for Tinnitus Therapy System

Desyncra is used for 4-6 waking hours daily for a period of 9 months. Longer daily or high-volume use is not recommended due to risk of auditory system injury. Results may vary depending on adherence, duration (number of months), and individual characteristics. While Wurzer et al., (2018) reported a 72%, improvement rate, a clinic in California reported a 90% success rate in relieving perception and loudness (Dr. S. Cohen, personal communication July 9, 2019).

Contraindications and Warnings (Desyncra users’ manual)
The Desyncra for Tinnitus Therapy System should not be used in individuals with

- Auditory hallucinations
- Symptomatic hearing disorders
- Meniere’s disease
- Brainstem diseases
- Psychiatric disorders
- Treatment of tinnitus in temporomandibular joint diseases
- Treatment of objective tinnitus
- Congenital or traumatic deformity of the ear
- Sudden or rapidly declining hearing acuity
Desyncra for Tinnitus Therapy System is usually well tolerated; however, some adverse effects may occur. An individual should stop using the device immediately and report the following:

- Decreased acuity
- Dizziness
- Increased loudness and pitch changes
- Anxiety
- Auditory hallucinations
- Nausea
- Headaches
- Palpitations

**Innovative technology: Desyncra for Tinnitus Hearing Aid**

Presently, individuals who use a hearing aid cannot use it during the 4-6 hours daily undergoing this therapy. However, the Desyncra hearing aid (Figure 3) is in development and is compatible with the Desyncra for Tinnitus Therapy System. Individuals with both decreased hearing and tinnitus (Dr. S. Cohen, personal communication; [www.desyncra.com](http://www.desyncra.com)) connect the hearing aid with the app and iPod via Bluetooth to augment hearing concurrently with delivering neuromodulation. In a case study (Hauptmann et al., 2017), this resulted in a 70% reduction in symptoms on the tinnitus handicap inventory (THI), a 32% improvement on visual analog scale (VAS) for loudness and annoyance, and 35% improvement on the standardized tinnitus questionnaire (TQ).

**Sound Therapy System**

The Levo Sound System (LSS) by Otoharmonics (Figure 4) delivers tinnitus-matched sound frequency to restore excitatory and inhibitory balance during sleep. Eventually, the brain gets used to the tinnitus sound, which is moved to the background and is no longer the primary processed sound stimulus. Studies using Levo demonstrated significant improvement in cognition and sleep (Theodoroff et al., 2017).

**The Levo Sound System: regulatory information, cost, and use** ([https://otoharmonics.com/regulatory](https://otoharmonics.com/regulatory)):

- FDA 510(k) cleared 5CE mark
- CSA (Canadian Standards Association) certification C-01-1171-673-19
- ISO (International Organization for Standardization) certification 13485, 2016 edition
- Compliant with IEEE (Institute of Electrical and Electronics Engineers) third edition, medical device electrical safety 60601-1-1-1.

The Levo Sound System Therapy includes:

- Apple iPod touch mobile digital device
- Software
- Flex-fit earbuds

Smart technology via Wi-Fi lets the individual and the professional to monitor use and individual progress.
Initially, the Levo Sound System is used nightly for a period of 3 months. After this, therapy can be resumed any time if an individual experiences increased loudness and annoyance after a traumatic or stressful situation.

Depending on provider location, the cost ranges between $4,000-$5,500. Set up requires 4-5 audiology visits: to assess hearing acuity and tinnitus characteristics, fitting, and three followups at 7-14, 30, and 90 days. (Matt Lopez, Levo System Otiharmonics, personal communication July, 2019).

The Levo System: Outcomes measures
Effectiveness is evaluated by comparing the pre- and the post-treatment outcome measurements on the Tinnitus Functional Index questionnaire. Although results vary between providers, in clinical settings, the Levo Sound System demonstrated a decrease of 21 points on TFI; a decrease of 13 points by any intervention is considered significant. (Personal communication with M. Lopez, July, 2019).

A randomized controlled trial by Pedemonte et al., (2014) evaluated the impact of Levo’s nocturnal sound therapy, finding it more effective when compared to either an unmatched tinnitus sound or a sound-unmatched traditional bedside noise generator. In a clinical audiology practice in California, Dr. Sharzad Cohen reports that an 85% success rate in loudness and related distress symptoms (Personal communication with Dr. S. Cohen, June, 20th, 2019).

Summary
Subjective tinnitus is a complex neurophysiological condition, generated, processed, and maintained by interactions in the cerebral auditory cortex and non-auditory brain regions. Evidence-based treatments such as cognitive behavioral therapy, sound therapy, and tinnitus maskers produce variable outcomes. Neuroplasticity and neumodulation-based hearing threshold-adapted coordinated reset (HTA-CR) and tinnitus-matched sound therapy demonstrate clinically and statistically significant improvement in reducing symptoms and improving quality of life.

References
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Retrieved from https://www.hindawi.com/journals/bmri/2015/569052 May 24, 2019

Nellie Kreimer has been a registered nurse since 1985. Ms. Kreimer is passionate about improving health and quality of life for those in need through advancement of nurse life care planning profession. Ms. Kreimer’s interests include neuroscience nursing, traumatic and acquired brain injury, and spinal cord injury. Ms. Kreimer can be contacted at nelliekreimer@gmail.com
REIMBURSEMENT RESOURCES

The following information is offered as a resource to providers seeking reimbursement for the evaluation and care of tinnitus patients using the Levo System. In no way does Otoharmonics represent or guarantee that the information outlined below will result in payment to patients or providers. Reimbursement rates and guidelines are determined without input or control of Otoharmonics. This information is intended as a reference only and should be used according to the billing standards set within your organization.

Suggested ICD codes

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<tr>
<th>Diagnosis</th>
<th>ICD-9</th>
<th>ICD-10</th>
</tr>
</thead>
<tbody>
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<td>Tinnitus, unspecified</td>
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<td>H93.19</td>
</tr>
<tr>
<td>Subjective tinnitus</td>
<td>388.31</td>
<td>H93.19</td>
</tr>
<tr>
<td>Objective tinnitus</td>
<td>388.32</td>
<td>H93.19</td>
</tr>
<tr>
<td>Tinnitus, right ear</td>
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<td>H93.11</td>
</tr>
<tr>
<td>Tinnitus, left ear</td>
<td>N/A</td>
<td>H93.12</td>
</tr>
<tr>
<td>Tinnitus, bilateral</td>
<td>N/A</td>
<td>H93.13</td>
</tr>
<tr>
<td>Hyperacusis</td>
<td>388.42</td>
<td>H93.23</td>
</tr>
<tr>
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<td>388.42</td>
<td>H93.231</td>
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<tr>
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<td>388.42</td>
<td>H93.232</td>
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<tr>
<td>Hyperacusis, bilateral</td>
<td>388.42</td>
<td>H93.233</td>
</tr>
<tr>
<td>Hyperacusis, unspecified</td>
<td>388.42</td>
<td>H93.239</td>
</tr>
<tr>
<td>Sensorineural hearing loss, unspecified</td>
<td>389.10</td>
<td>H90.5</td>
</tr>
<tr>
<td>Sensorineural hearing loss, unilateral right</td>
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<td>H90.41</td>
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<td>Sensorineural hearing loss, asymmetrical</td>
<td>389.16</td>
<td>H90.5</td>
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<tr>
<td>Sensorineural hearing loss, bilateral</td>
<td>389.18</td>
<td>H90.3</td>
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</table>

Suggested CPT codes

<table>
<thead>
<tr>
<th>Initial Assessment</th>
<th>Description</th>
</tr>
</thead>
</table>
| 92587 or 92588                       | Otoacoustic emissions
Otoacoustic emissions  Distortion product evoked otoacoustic emissions |
|                                    | Use 92587 for a limited evaluation (to confirm the presence or absence of hearing disorder, 3–6 frequencies) or transient evoked otoacoustic emissions, with interpretation and report. |
|                                    | Use 92588 for a comprehensive diagnostic evaluation (quantitative analysis of outer hair cell function by cochlear mapping, minimum of 12 frequencies), with interpretation and report. |
| 92567                               | Tympanometry and Eustachian tube dysfunction measures                        |
|                                    | Use when tympanometry has been performed.                                   |
| 92557                               | Comprehensive audiometry threshold evaluation and speech recognition         |
|                                    | Use when a comprehensive evaluation has been performed.                     |
| 92625                               | Tinnitus assessment                                                         |
|                                    | Use the Levo Manager to perform pitch, loudness, sound match and masking.   |
| 98960 or 98961                      | Education and Training for patients                                         |
|                                    | Use the standardized educational materials provided by Otoharmonics to educate patients on the condition of tinnitus as well as how to use the Levo System for therapy. |
|                                    | Use 98960 for training the patient only.                                    |
|                                    | Use 98961 for training the patient and family.                             |

Levo System

| 92700                               | Unlisted otorhinolaryngological service or procedure                        |
|                                    | Use when the Levo System has been prescribed. Submit with patient record and the suggested Letter of Medical Necessity. |

Ongoing Care

| 92626 and 92627                     | Evaluation of auditory rehabilitation status                                |
|                                    | Use 92626 for the 1st hour of care. Use 92627 for each additional 15 minutes of care. |
| 98960 or 98961                      | Education and Training for patients                                         |
|                                    | Use the standardized educational materials provided by Otoharmonics to educate patients on the condition of tinnitus as well as how to use the Levo System for therapy. |
|                                    | Use 98960 for training the patient only.                                    |
|                                    | Use 98961 for training the patient and family.                             |
DEAR NURSE LIFE CARE PLANNERS,

I had one of the best lunches this past week! Yes, it was a typical Pittsburgh menu item- Pierogis with sour cream, bacon, cheese, and jalapeños – but this is not what made it so great. My lunch guests were my new friends and our 2020 Conference Keynote Speakers Nathan Copeland, Hannah Glagola, and Dr. Kristin Quick.

Here is a little background on this Pittsburgh lunch before I jump into sharing our lunch conversation:

Nathan Copeland was 18 years old when a car accident caused his quadriplegia in 2004. Nathan is the first human to have microelectrode arrays implanted in his sensory cortex. For the last 5 years Nathan has participated in a brain-computer interface study through the Rehab Neural Engineering Labs (RNEL) at University of Pittsburgh. By using his neural activity recorded from the embedded arrays in his motor and sensory cortices, he can self-control a robotic arm and receive sensations in return.

Dr. Kristin Quick is a Neurotechnology Scientist in the Department of Physical Medicine and Rehabilitation at the University of Pittsburgh. Her PhD work focused on improving brain-computer interfaces through understanding the underlying neural manifold of motor cortex, as well as investigating methods to assess sensorimotor performance. Dr. Quick’s research interests include understanding how interactions between motor cortex and sensory cortex enable dexterous upper limb movements. Her goals also include learning about the roles of contralateral and ipsilateral cortex in the control of movements to develop bilateral brain-computer interfaces.

I know it!!!! It was such a fantastic day with fascinating conversation. I can’t wait for you to experience the same thing at the conference! OOH and I got to go to the lab; you will too-virtually! Dr. Quick will be joining us from RNEL while Nathan joins us in San Diego.

With Dr. Quick’s assistance, we have put together Rehab Neural Engineering Labs’ extensive publication list, which lays the foundation of combining science, medicine, and pathophysiology behind the conversation I am permitted to share with you.

Restoring touch through intracortical microstimulation of human somatosensory cortex, a study published 2017 under an Investigation Device Exemption, shows a twenty-eight year old participant with a long-term cervical spinal cord injury who was implanted with two microelectrode arrays in primary motor cortex (M1) and two microelectrode arrays in primary somatosensory cortex (S1). Intracortical microstimulation (ICMS) in S1 offers a potential method to restore somatosensory perception in persons that have lost this function through injury or disease.

Paraphrasing the 2018 abstract Progress towards restoring upper limb movement and sensation through intracortical brain-computer interfaces, ‘Decades of research on motor control have enabled remarkable demonstrations of brain-controlled arm and hand movements in people with paralysis. Bidirectional brain-computer interfaces (BCIs) make use of neural recordings to restore movement while conveying somatosensory information back to the user through direct stimulation of
the nervous system. Recent efforts to restore somatosensation have shown that intracortical microstimulation of somatosensory cortex can generate focal, graded, and digit-specific sensations after chronic spinal cord injury. The combination of BCI-enabled motor control and sensation is an area of recent investigation for human clinical studies, and the interplay between these two domains represents an opportunity for scientific discovery.

The natural question is, what does it feel like? Here’s Nathan’s answer!

Q: (Dr. Quick): Soooo we normally start on the same channel, and it feels like it’s coming from where?

A: (Nathan): My index knuckle, and it feels like, a, a pressure – tingle. Sometimes it’s warm.

Q: (Dr. Quick): What kind of warm?

A: (Nathan): It’s kind of like when you take a shot of vodka and you’re warm on the inside. It’s not like, getting burned, or, you know, touching something hot.

Q: Does it ever feel too hot?

A: I have not experienced any sensations that have been too hot or what I would even consider painful.

Q: Ok. What…would you call any of the sensations funny? (laughter)

A: So there’s this one sensation that we just – somehow it got named ‘sparkly’ and every time I feel it it’s in like the base of my index finger, like, the pad, um and it just feels like, uh like a rapid tapping but it kind of moves around a little bit and it – I don’t know, it just makes me smile every time I feel it. I don’t know what it is, it’s just kind of (laughter)

Q: Sparkly?

A: Sparkly – like a sparkler or like fireworks? Where it’s like a central location like… (lots of directional words where the interviewer is trying to find the area on his hand he’s talking about). Right there. So, it’s in that area, but it’ll be like kind of little bursts, so it might not be like -yeah – but in that one area. So somehow, sparkly came up.

Q: And would you say that sensation feels unnatural?

A: Oh…naturalness is a whole can of worms because I get asked how natural things feel and I usually say, you know, it gets completely unnatural to completely natural and possibly natural is right in the middle. So most of them I just say “it’s possibly natural” because it, it’s not – like it doesn’t feel weird enough that I would say “unnatural” but sometimes I don’t, I can’t think of like a real world like, analog, of “this feels like this”. So, until I can figure that out, I usually say “possibly”. Um…sparkly….is just kind of weird. I mean it would probably be more towards unnatural, but not in a bad way. You know, I think that’s why it makes me smile cause I’m just like “this feels so weird, like…”

Q: Does it feel like a tickle? Like you’re laughing ‘cause you’re getting tickled…

A: Yeah It’s like a tickle, like pressure, ’cause it feels like deep pressure and then it’s like, moving around and then it’s like I feel like four, five quick like pulses and I don’t know. And it only happens at 20 Hertz on this one electrode which is not the, the normal, everyday stimulation frequency that gets done, it’s like 100? 60?

Q: 100

A: 100 Hertz

Q: Have you felt like over the years you can identify which electrode is being tested?

A: (Laughter) Some of them, yeah.

Q: But not all of them?

A: Not all of them. There’s too many. And then lots of them just basically feel like the same…thing? I guess they’re probably all close together…

Q: Yeah

A: And I’ll feel like, like the same thing when they go.

Q: Do they feel any different based off
of like what finger they’re on? Like any consistent pattern based off of where they are?

A: Hmmm

Q: Like I know for the thumb sometimes there’s – you say you can feel it on the front or the back or maybe I’m remembering that wrong.

A: The thumb sometimes I’ll feel like, warm on the thumb, like, pad. But then, yeah, so for index [finger], I’ve I have stuff on the palm, like down by the palm, and then the index knuckle. And then sometimes down the back of the finger. And then pretty much all the other fingers I’ll only feel, um, there at the palm side um, occasionally there’s one or two that I feel like there’s some tingling down the back of the middle finger. And those are, I think, all one’s that also have tingling down the back of the index finger –

Q: Hmm

A: So, it’s like the same combo deal

Q: Hmm

Best,
Kelly Campbell

PS: I absolutely cannot wait for you to meet Nathan. He is so insightful on so many levels. Did you ever think about travel and first class for SCI? The reason- recline for wound management. Did you ever think about inclusion of travel for attendant/caregiver for quadriplegia during travel? The reason- it is not a luxury but a necessity. Be sure to talk to him- you will learn so much! He is funny with so many great stories! He has traveled to Japan, he has met and fist pumped President Obama, and he loves cats!

Nathan Copeland, Dr Kristin Quick and RNEL assisted and approved.
Additional Reading: Summary paragraph from Restored tactile sensation improves neuroprosthetic arm control:

The sense of touch is critical for skillful hand control but is largely missing for people who use prosthetic devices. Instead, prosthesis users rely heavily on visual feedback, even though state transitions that are necessary to skillfully interact with objects, such as object contact, are relayed more precisely through tactile feedback. Here we show that restoring tactile sensory feedback, through intracortical microstimulation of the somatosensory cortex, enables a person with a bidirectional intracortical brain-computer interface to improve their performance on functional object transport tasks completed with a neurally-controlled prosthetic limb. The participant had full visual feedback and had practiced the task for approximately two years prior to these experiments. Nevertheless, successful trial times on a commonly used clinical upper limb assessment task were reduced from a median time of 20.9 s (13.1 - 40.5 s interquartile range) to 10.2 s (5.4 - 18.1 s interquartile range) when vision was supplemented with microstimulation-evoked cutaneous percepts that were referred to different fingers and were graded in intensity based on real-time prosthesis contact forces. Faster completion times were primarily due to a reduction in the amount of time spent attempting to grasp objects. These results demonstrate the importance of tactile sensations in upper-limb control and the utility of creating bidirectional brain-computer interfaces to restore this stream of information using intracortical microstimulation. This study was conducted under an Investigational Device Exemption from the U.S. Food and Drug Administration and is registered at ClinicalTrials.gov.


Kelly Campbell, RN, BSN, CP, CLNC, CLCP, Founder

After a career in healthcare spanning over 20 years, Kelly realized the value she could provide at the intersection of the medical and legal industries—she decided to create CARDINAL LifeCare Consulting. Her experience working at a national clinical level as a nurse and perfusionist has made her an expert on policy procedures, orientations, standards of care and more.

During her years as a clinical specialist, Kelly participated in the first robotic heart surgery in the nation, including the development of an international clinical outcomes study as well as the implementation of a training course for Remote Access Perfusion (RAP) Cannula.

As a sales manager and educator, Kelly has worked with executives, physicians, managers, surgeons, specialists, nurses and more to convert them to new, innovative techniques. She applies these same skills daily as a life care planner to ensure she presents juries with facts in the clearest, most effective way.

Kelly is a Contributor and Reviewer for American Association of Legal Nurse Consultants (AALNC) 4th Edition Principle Practice; Chapter Author AALNC 4th Edition Principle Practice; Director at Large Pittsburgh AALNC; President-Elect Pittsburgh AALNC; Member American Association Nurse Life Care Planner Executive and Committee Chair Board; Chapter Author for upcoming Core Curriculum Nurse Life Care Planning, Reviewer for Journal Nurse Life Care Planning; past Co-Chairman and Chairman for the Journal of Nurse Life Care Planning; Member of Board of Directors for Western Pennsylvania Visiting Nurses Association – Hospice and Lutheran Senior Life, a Preceptor for Duquesne University Graduate School of Nursing, Forensic Clinical Nursing/Life Care Planning/ Legal Nurse Consulting; a published author and accomplished speaker.

Kristin Quick, PhD

Kristin Quick, PhD, is a Neurotechnology Scientist in the Department of Physical Medicine and Rehabilitation at the University of Pittsburgh. She completed her doctoral studies in Bioengineering at University of Pittsburgh in 2015. Her PhD work focused on improving brain-computer interfaces through understanding the underlying neural manifold of motor cortex as well as investigating methods to assess sensorimotor performance.

Nathan Copeland

Nathan Copeland was 18 years old when a car accident caused his quadriplegia in 2004. This catastrophic event often left him feeling like he would no longer be able to accomplish much with his life. Years later when presented the opportunity to help shape future technologies that could eventually benefit people in similar situations, he couldn’t refuse. For the last 5 years Nathan has participated in a brain-computer interface study through the University of Pittsburgh. Using microelectrode arrays implanted in his motor and sensory cortices he is able to control a robotic arm and receive sensations back from it. Nathan was the first human to have arrays implanted in his sensory cortex.

While his time with the research study will come to an end, Nathan has built up a wealth of experience that will stick with him for the rest of his life, from meeting President Obama to giving presentations in Japan. He hopes to continue sharing his story and insights into using an implanted BCI with anyone that would find them valuable.
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VENTRICULOOPERITONEAL SHUNTS: NURSE LIFE CARE PLANNING CONSIDERATIONS

Kirsten Turkington DNP, APRN, FNP-C, CNLCP

Abstract
Nurse Life Care Planners (NLCPs) write long-term care plans for patients with lifelong medical conditions, many with neurological conditions such as stroke and traumatic brain injury. In certain circumstances, NLCPs encounter patients needing neurologic shunts. A ventriculoperitoneal shunt (VPS) is one of several medical devices used to drain cerebrospinal fluid (CSF) away from the brain and into the peritoneum.

Introduction
Ventriculoperitoneal shunts (VPS) are one of a variety of devices used in neurological conditions, to divert cerebrospinal fluid (CSF) fluid into extracranial spaces. As the name implies, they drain ventricular fluid to the peritoneum. Once there, the fluid is resorbed into the circulation (Pan, 2018). This diversion alleviates cerebral pressure, improves cerebral perfusion, and preserves quality of life compromised by headaches, balance disturbances, and other physical manifestations of elevated CSF pressures. NLCPs must understand VPS systems, specific surgical considerations, and post-operative care needed when developing long-term care plans.

Background
Ventriculoperitoneal shunt systems were first used over 60 years ago, continuing to evolve with technological, materials, and clinical advances. Feasibility studies began in the early 1900s; however, systems were not formally developed and fully implemented until the 1950’s (Dutta, Srivastava, Jagetia, Singh and Singh, 2018; Hasan, Sharma, Chopra, & Purohit, 2018). Enhanced technology, improved physician training, and detailed understanding of CSF flow and pressure evaluation techniques resulted in dramatic medical improvements. Use of VPS systems is now standard neurosurgical practice to improve quality of life (Hasan, Sharma, Chopra, & Purohit, 2018).

There are several other types of shunts that drain CSF, though not as commonly used. The ventriculopleural shunt drains into the pleural cavity. Complications from respiratory insufficiency make these types rare today. Ventriculostrial shunts drain into the right atrium, presenting a different set of potential challenges, complications, and increased costs. Ventriculoperitoneal shunts are the most commonly used (Gayretli Aydin et al., 2018).

Premature or very small infants may need a shunt before insertion of a VPS, due to rapid growth seen in childhood. The subgaleal shunt, placed into a pocket beneath the subgaleal space (between the periosteum and the scalp), is used as a temporary measure (Fowler and Mesfin, 2018). As the child grows, these shunts are later converted to a ventriculoperitoneal (VP) or other shunt.

Knowing about conditions warranting shunt placement will help the Nurse Life Care Planner understand shunt types, insertion, and followup care, all necessary considerations for Life Care Plans, nursing care plans, and other clinical formats.

KEY WORDS:
Hydrocephalus, hydrocephalus ex vacuo, idiopathic intracranial hypertension, spina bifida, VP shunt, ventriculostomy

NURSING DIAGNOSES TO CONSIDER
NANDA-I 2017-2018

1. Risk for acute confusion.
   (Domain 5, Perception/cognition; Class 4, Cognition)
2. Risk for infection of implanted device.
   (Domain 11, Safety/protection; Class 1 Infection)
Risk for surgical site infection.
   (Domain 11, Safety/protection; Class 1 Infection)
Conditions Treated
CSF has three main life-supporting functions: brain buoyancy, nutrient delivery with waste removal, and compensation for blood flow between the cranium and spine (NINDS, 2019). VPS are most commonly used for hydrocephalus, but can also be used in tumors, brain cysts, and mechanical obstruction (Fowler and Mesfin, 2018; Gayretli Aydin et al., 2018; Hasan, Sharma, Chopra, & Purohit, 2018; Memorial Sloan Kettering Cancer Center, 2019; Pan, 2018; Prakash, Dhandapani, Ghai, Singh, & Dhandapani, 2018). It is important to understand the dynamics of CSF flow to fully appreciate the role shunt systems have in treatment and subsequent management of hydrocephalus. A CSF flow summary is provided below, but a more detailed discussion can be found here: https://www.hydroassoc.org/brain-101-the-ventricles-and-csf-flow/

CSF is created in the brain’s ventricular system by specialized tissue known as the choroid plexus. Beginning in the lateral ventricles, it flows through two passages into the third ventricle, and then flows through the aqueduct of Sylvius, a long narrow tube, into the fourth ventricle. Brain tissue may also provide a path to the subarachnoid space. CSF is primarily absorbed through blood vessels in the brain and returned to the blood stream. Smaller amounts are also absorbed into lymphatic channels.

The production process is age-dependent, producing approximately 500 ml daily (20 ml/hour), usually

Figure 1
balanced between creation of the CSF and absorption. Approximately 150 ml of CSF flows around the brain and spinal cord starting at about 5 years of age into adulthood (Jea & Kulkarni, 2019).

Hydrocephalus results from an imbalance between CSF production and absorption with excess accumulation (Korulmaz, Alakaya, Kaya, Hamzaoglu, Tezol, & Arslankoylu, 2019). Underlying causes fall into several broad categories, which may overlap: congenital, acquired, obstructive, or communicating hydrocephalus. This causes increased cerebral pressure, increased pressure on delicate brain tissues, and decreased blood and oxygen delivery at the cellular level with potential for cellular death. Manifestations depend on pressure location and tissue damage and require prompt recognition and diversion of excess CSF to alleviate intracranial or cerebral pressure and decrease brain tissue swelling (Fowler and Mesfin, 2018) to avoid future complications. Ongoing management of related conditions is also essential.

Hydrocephalus is initially classified as either congenital or acquired (NINDS, 2019) at time of diagnosis. Congenital hydrocephalus accounts for approximately 50% of cases, mostly presenting in infancy. Common types of congenital hydrocephalus are aqueductal stenosis (narrowing of the CSF flow pathways), blockage of CSF brain flow by fluid filled arachnoid cysts, Dandy-Walker syndrome (a cerebellar brain malformation) and Arnold-Chiari malformation where the cerebellar tonsils obstruct CSF flow at the foramen magnum (Hydrocephalus Association, n.d.). Spina bifida is another congenital form that usually presents at birth; however, certain types of spina bifida can also be identified in pregnancy. Treatment of congenital hydrocephalus is necessary to minimize future complications.

Acquired hydrocephalus occurs months to years after birth, caused by infection or actual brain damage. Intraventricular hemorrhage, meningitis, traumatic head injuries, and brain tumors, among others, are contributory (Hydrocephalus Association, n.d.). Regardless of the cause, failure to adequately diagnose and properly treat hydrocephalus can damage brain and nerve tissues. Hydrocephalus is further classified into two commonly defined subtypes: obstructive or communicating (Pan, 2018). However, hydrocephalus ex-vacuo (HEV) and normal pressure hydrocephalus (NPH) can also occur, but do not meet strict criteria for either obstructing or communicating hydrocephalus. Both HEV and NPH occur primarily in adults (NINDS, 2019).

**Obstructive Hydrocephalus**
Obstructive hydrocephalus is the result of blockage(s) in any of the narrow ventricular fluid pathways, and warrants shunt placement. (NINDS, 2019). Examples of obstructive conditions include:
- brain tumor
- spina bifida (cerebellum blocks CSF flow)
- congenital aqueductal stenosis,
- craniosynostosis
- post-meningitic conditions
- Dandy-Walker syndrome
- arachnoid cysts
- idiopathic intracranial hypertension (Fowler and Mesfin, 2018).

**Communicating Hydrocephalus**
Communicating (nonobstructing) hydrocephalus relates to flow exiting the ventricles. This is most commonly caused by defective CSF absorption (Nelson, 2018). CSF overproduction is an additional form of communicating hydrocephalus, but less common. Venous drainage, meningitis, and hemorrhage are examples of communicating hydrocephalus. These conditions benefit significantly from shunt placement (Bradley, 2016).

**Hydrocephalus Ex-Vacuo**
Hydrocephalus ex-vacuo (HEV) typically occurs with stroke or traumatic brain injury and is classified separately from obstructive or communicating types. It causes the brain tissue to shrink (encephalomalacia) (NINDS, 2019), enlarging the ventricles and the subarachnoid space. This is much more common in older adults; however, younger adults can also present with cerebral dystrophy and secondary HEV after a history of traumatic brain injury. Periodic MRIs, e.g., every 3-5 years and when changes in neurological function present, are often part of long-term monitoring post traumatic brain injury for this reason.

**Normal Pressure Hydrocephalus**
Normal pressure hydrocephalus (NPH) is an abnormal increase of cerebrospinal fluid in the brain’s ventricles (NINDS, 2019). Anatomically, CSF continues to flow, but ventricles may or may not dilate. Rather, depending on the underlying cause, ventricles may appear almost slit-like on MRIs. NPH may result from a subarachnoid hemorrhage, head trauma, infection, tumor, or complications of surgery.
Specific underlying causes are unknown in many cases.

Idiopathic normal pressure hydrocephalus (iNPH) varies slightly from traditional NPH in several ways and primarily affects older adults (Benveniste, 2018). MRI commonly demonstrates enlarged ventricles without increased intracranial pressure (Hung, 2016). Idiopathic NPH is characterized by a clinical triad of gait disturbance, dementia, and urinary incontinence (Bradley, 2016). Idiopathic intracranial hypertension (IIH), until recently known as pseudotumor cerebri, causes similar symptoms to iNPH but has dissimilar radiographic findings. It also typically affects younger women without any known trigger or underlying cause (National Center for Advancing Translational Sciences, 2019).

Many people develop NPH when none of these factors are present and underlying causes are never identified (NINDS, 2019). An estimated 375,000 older Americans have NPH and some older symptomatic patients that respond well to lumbar tap tests are treated with permanent shunts (Hung, 2016). Similarly, patient with IIH are can also benefit from shunt placement, although specific etiology for why this is so beneficial is yet unclear.

Anatomy of Ventriculoperitoneal Shunts

Shunts differ in materials, valve types, and whether the valve is programmable or not (Fowler and Mesfin, 2018). Older ventriculoperitoneal shunts are usually composed of three parts: a short inflow catheter, a valve mechanism, and a longer outflow catheter (Hydrocephalus Association, n.d.).

The inflow catheter is a small tube inserted into the ventricles or the subarachnoid space through a burr hole in the skull. The catheter leaves the brain through the skull and is tunneled under the skin. This tube is connected to a one-way valve mechanism, which includes the valve housing and reservoir. There may be an inline sampling port to facilitate direct CSF sampling. The mechanism stays between the skull and skin, usually on top of the head or behind an ear. The longer outflow catheter under the skin drains CSF through a valve mechanism and thence to a more distal site for absorption. For VPS systems, this is the peritoneum (Hydrocephalus Association, n.d.; Memorial Sloan Kettering Cancer Center, 2019). Newer shunt systems are one piece, rather than three, but follow the same design principles. (Masoudi, Rasafian, Naghmehsanj, & Ghaffarpasand (2017).

The shunt valves can either be fixed (nonprogrammable) or variable pressure (programmable) (Memorial Sloan Kettering, 2019; Soler, Bao, Jaiswal, Zaveri, Diluna, Grand and Hoshino, 2018). Commonly used fixed valves are the PS Medical Delta® and the Codman Hakim Precision Valve®, as well as the Aesculap MIETHKE. Specific valve selection depends on the surgeon’s comfort, experience, training, and available scientific evidence (Soler, Bao, Jaiswal, Zaveri, Diluna, Grand and Hoshino, 2018).

Programmable shunts

Programmable shunts technology is changing rapidly. Programmable shunts commonly use ball valve systems, with or without magnetic rotators, to manage intraventricular CSF pressure within a physiologically acceptable range (Scholz, Stengel, Lemcke, & Meier, 2018). This is an important concept to protect patients from either over- or under-drainage.

With programmable valves, the physician programs the settings before surgery. The greatest challenge is proper selection of opening pressures at the time of implantation (Soler, Bao, Jaiswal, Zaveri, Diluna, Grand and Hoshino, 2018). Too much drainage results in symptoms that are quite similar to hydrocephalus and shunt settings often need postoperative adjustments, so thorough assessments and close follow up are essential.

After hospital discharge, ongoing adjustments are usually done in an outpatient clinic visit. Some programmable shunts also use anti-siphon devices to manage the risk of over-drainage from excess gravitational CSF flow with position changes from sitting to standing. Programmable shunts are further affected by over- and under-drainage concerns with underdrainage having a more pronounced negative impact on patient outcomes (Scholz, Stengel, Lemcke, & Meier, 2018).


Procedure

Ventriculoperitoneal shunt insertion is a hospital surgical procedure that takes approximately one hour. VPS systems
are inserted by neurosurgeons in the operating room. Patients are prepped and draped in sterile fashion, a portion of hair is shaved and three small incisions are made (Fowler and Mesfin, 2018, Memorial Sloan Kettering, 2019). The first incision is near the site of initial shunt insertion in the head. This first incision includes placement of the proximal inflow catheter. The second incision is in the patient’s neck or scalp, allowing appropriate placement of the selected valve mechanism. The third incision is in the abdomen allowing the distal catheter placement into the peritoneum. The catheter is not usually visible, but some patients may feel the catheter tubing along their neck. A raised area may be visible in patients with low body mass indices.

VPS insertion requires preoperative testing appropriate to patient age and condition, need for general anesthesia, operating room, recovery room and hospital room stays (Fowler and Mesfin, 2018). Infection overlying the insertion site is an absolute contraindication to VPS insertion. Coagulopathy, inappropriate preoperative evaluation and lack of shunt imagery would be relative contraindications (Fowler and Mesfin, 2018). Hospital nursing care is required in all follow up areas with frequent neurological and wound checks to assess for complications. Patients with VPS requiring a one to two night stay post-insertion (Memorial Sloan Kettering Cancer Center, 2019). The exact duration of the hospital stay is dependent on many factors, including what condition is being treated, patient age, clinical condition and medical history.

**Complications**

Ventriculoperitoneal shunts come with significant risk of complications. Biotechnology is rapidly advancing shunt composition to reduce malfunctions and optimize patient outcomes. However, despite these technological advances, shunt related complications continue to plague patients and the greater neurosurgical community (Dutta, Srivastava, Jagetia, Singh and Singh, 2018; Masoudi, Rasafian, Naghmehsanj, & Ghaffarpasand, 2017; Pan, 2018). Shunt failure is the number one reason for revision (Soler, Bao, Jaiswal, Zaveri, Diluna, Grand and Hoshino, 2018). Complications lead to increased patient risk and additional healthcare costs and are a major cause of adult and pediatric morbidity and mortality (Gayretli Aydin et al., 2018).

Complication estimates vary widely. Generally, complications vary between 5% and 70% of all new and revision cases, however, more refined studies reflect significant complication rates of 40% within the first two years and 98% within the first 10 years (Chugh, Gotecha, Amle, Patil, Punia, & Kotecha, 2019; Dutta, Srivastava, Jagetia, Singh and Singh, 2018, Hasan, Sharma, Chopra, & Purohit, 2018; Masoudi, Rasafian, Naghmehsanj, & Ghaffarpasand, 2017; Soler, Bao, Jaiswal, Zaveri, Diluna, Grand and Hoshino, 2018). Johns Hopkins Medicine Department of Neurology and Neurosurgery (n.d.) indicates difficulty with predicting complications, noting that about ½ of all shunts need to be either revised or replaced after six years.

Agarwal et al. (2019) specifically studied revision rates specific to types of valves and durability of the equipment. They found valve revision rates to be relatively equal with approximated 22% for programmable pressure valves and 21% for fixed pressure valves. Participants had no average differences in durability between fixed valves (39 months) and programmable valves (40 months). Therefore, it is VPS complications often require additional procedures, increased hospitalizations, additional surgery, and may result in mental retardation and persistent neurological deficits (Chugh, Gotecha, Amle, Patil, Punia, & Kotecha, 2019, Gayretli Aydin et al., 2018). It is reasonable to include these general timeframes for revision with recognition that close follow up and ongoing LCP evaluations are necessary.

There are many possible complications with VPS placement. Infections, mechanical shunt failure, and abdominal complications are all possible outcomes (Hasan, Sharma, Chopra, & Purohit, 2018; Masoudi, Rasafian, Naghmehsanj, & Ghaffarpasand, 2017). Shunt failure for any reason increases patient morbidity and contributes to lifelong problems such as headaches, epilepsy, cognitive impairment and urinary incontinence (Prakash, Dhandapani, Ghai, Singh, & Dhandapani, 2018).

Infections are the most commonly identified reason for shunt revisions and usually present within the first two months of insertion (Gayretli Aydin et al., 2018; Hung, 2016). These complication concerns have significant potential to impact activities of daily living and quality of life considerations with care planning. A thorough understanding of how hydrocephalus separates into specific complications into mechanical or functional definitions benefits overall planning strategies (Pan, 2018).

**Shunt Complications**

Mechanical shunt complications are broken down into obstruction, disconnection and migration of shunt components such as catheter displacement away from the original site of insertion (Pan, 2018). There is also high prevalence of abdominal complications with VPS systems. Shunt obstruction is the most common mechanical complication overall.
Disconnection is most common in multi-piece shunts. Shunt separation is a well-known complication occurring in approximately 15% of cases (Ghritlaharey, 2019). Newer one-piece shunt systems eliminate the risk of separation. Dutta, Srivastava, Jagetia, Singh and Singh (2018) found the most common abdominal complications included peritonitis, ascites, inguinal hernia and perforation of the bowel or bladder wall.

Additional abdominal complications included inguinal hernias, hydroceles and ascites (Masoudi, Rasafian, Naghmehsanj, & Ghaffarpasand, 2017). Abdominal complications also include concerns such as spontaneous coiling of intact shunts and extrusion through anal and vaginal orifices (Chugh, Gotecha, Amle, Patil, Punia, & Kotecha, 2019; Dutta, Srivastava, Jagetia, Singh and Singh, 2018, Hasan, Sharma, Chopra, & Purohit, 2018; Saha, Burman, Saha, & Ghosh, 2018; Korulmaz, Alakaya, Kaya, Hamzaoglu, Tezol, & Arslankoylu, 2019).

Migration can also be defined by slippage of the surgical wound and migration of the distal end outside the peritoneum (Hasan, Sharma, Chopra, & Purohit, 2018, Saha, Burman, Saha, & Ghosh, 2018). This is particularly notable because abdominal complications or extrusion potentially expose the shunt to a nonsterile environment. When catheter displacement occurs, the shunt is usually intact. A displaced, intact shunt presents a clear pathway for retrograde infection in the encephalitis or meningitis (Dutta, Srivastava, Jagetia, Singh and Singh, 2018). Migration of the distal shunt end into the thoracic cavity (rather than peritoneum) has contributed to pneumonia and hydrothorax (Saha, Burman, Saha, & Ghosh, 2018), causing additional procedures, treatments and increased costs. Shunt migration is further complicated by potential visceral perforation or puncture.

Other mechanical complications include pseudocyst formation (Masoudi, Rasafian, Naghmehsanj, & Ghaffarpasand, 2017). Pseudocysts are particularly ominous complications and are poor prognostic indicators for future peritoneal shunt use (Masoudi, Rasafian, Naghmehsanj, & Ghaffarpasand, 2017).

Functional complications are conditions where the shunt is unable to effectively function despite proper placement. Functional complications include ventriculitis, tract abscess, and skin necrosis overlying the shunt device (Pan, 2018).

**Pediatric Considerations**

Children have additional considerations relative to shunt failure and subsequent complications. Unfortunately, the need for shunt revisions is higher in pediatric cases (Ghritlaharey, 2019). Headache, generalized pain and fatigue are common presentations of shunt failure (Prakash, Dhandapani, Ghai, Singh, & Dhandapani, 2018). Shunt complications can impact body growth, physical and emotional development and academic progress, resulting in deterioration of functional status and potential for disability (Prakash, Dhandapani, Ghai, Singh, & Dhandapani, 2018).

Regardless of the underlying VPS complication, problem correction is necessary. Appropriate infection control precautions and the possibility of alternate procedures to divert CSF are requirements for optimized care (Hasan, Sharma, Chopra, & Purohit, 2018).

**Follow up care**

Unless complications occur, follow up care is outpatient and consists of ongoing wound care, outpatient clinic visits, and neurosurgeon evaluations. Nurse Practitioners or Physician Assistants may do follow up visits with VPS patients, depending on the surgeon and healthcare facility guidelines.

Imaging is necessary for follow up shunt evaluations. Recommendations include Cranial Computerized Tomography (CT) with a shunt series (Dutta, Srivastava, Jagetia, Singh and Singh, 2018). Suspicions of pseudocyst formation require a high index of suspicion and further diagnostic evaluations (Masoudi, Rasafian, Naghmehsanj, & Ghaffarpasand, 2017). The principal diagnostic techniques include abdominal ultrasound or CT scan (Masoudi, Rasafian, Naghmehsanj, & Ghaffarpasand, 2017). However, infants six months of age and younger require an ultrasound.

Ultimately, in all cases of VSP placement, close clinical follow up and ongoing radiographic imaging is recommended. Cognitive considerations, socioemotional and socioeconomic aspects must be addressed alongside physical manifestations (Prakash, Dhandapani, Ghai, Singh, & Dhandapani, 2018). Children require close oversight to insure growth and development progresses as expected. Academic evaluations and ongoing supports (tutoring, independent educational evaluations, specialized instruction) may be necessary for the student to progress alongside their peers. Behavioral changes may necessitate psychology, psychiatry or neuropsychiatry evaluations as part of the process (Prakash, Dhandapani, Ghai, Singh, & Dhandapani, 2018).

**Costing**

Estimating VPS costs is difficult because of limited
availability for large scale cost analysis research in adults. Limited pediatric studies found that median shunt supply costs per case and accounting for subsequent revisions was $3438 for programmable shunts and $1504 for fixed shunts. These numbers do not account for facility fees, diagnostic fees, procedures and additional nonshunt related supplies such as nursing time, rehabilitation or other significant cost contributors.

Considerations for specific treatment conditions, identified complications, known comorbidities, neurosurgical expertise and procedural technique also impact cost estimates. Fees also vary based on region and resources available. According to MDsave, the national average cost for shunt revision at $17,608 but with regional limitations on where the procedure could be performed. One study found that initial surgical shunt management of hydrocephalus was $13,989 but skyrocketed to $83,649 for infection related revisions (Soler, Bao, Jaiswal, Zaveri, Diluna, Grand and Hoshino, 2018). An outdated ventricular shunt study from 2005 demonstrated an average cost of $35,816 with upper end pricing of $814,748 for each procedure (Patwardhan & Nanda, 2005). This wide pricing range with limited current research significantly complicates the overall financial picture for what NLCPs can expect for cost.

**Coding**

VPS coding requirements directly relate to the underlying conditions, specific procedures, shunt materials and clinical recommendations. Nurse Life Care Planners must understand the specific underlying condition for which VPS placement is necessary. There must be further appreciation of the levels of definition needed to properly identify the ICD-10 diagnosis code. The next sections review specific diagnosis and current procedural terminology codes for care planner review.

**Diagnosis Codes**

Selecting the proper diagnosis code can be intimidating, but it does not need to be. Diagnoses of the nervous system range from G00-G99. Congenital hydrocephalus, the type present at birth, is globally identified by the ICD-10 code of Q03, but additional details are necessary for proper reimbursements. This classification separates into Malformations of the aqueduct of Sylvius (aqueductal stenosis, Q03.0), Other congenital hydrocephalus (Q03.8) and Congenital hydrocephalus, unspecified (Q03.9). Exclusions to this diagnostic category include any conditions that mix congenital with acquired anomalies. This includes Arnold-Chiari syndrome, acquired hydrocephalus and hydrocephalus with spina bifida.

The diagnosis codes used to document the indication for VPS placement are dependent on the specific underlying cause of hydrocephalus. Acquired Hydrocephalus is globally specified by G91 and also needs multiple codes to provide appropriate detail. The two most common example codes include Communicating hydrocephalus (G91.0), and Idiopathic Normal pressure hydrocephalus (iNPH) (G.91.2) with the latter recognized as the default. In all, there are seven subcategories to choose from and are reflected in Table 1.

There are also initial encounter diagnosis codes reflective of shunt function. These codes primarily define

<table>
<thead>
<tr>
<th>Table 1. Hydrocephalus ICD-10 Codes</th>
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<tbody>
<tr>
<td><strong>Congenital Hydrocephalus</strong></td>
</tr>
<tr>
<td>Q03.91</td>
</tr>
<tr>
<td>Q03.1</td>
</tr>
<tr>
<td>Q03.8</td>
</tr>
<tr>
<td>Q03.9</td>
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malfunction, breakdown and displacement of the shunt. Additional details can be found in Table 2. Coding for VPS can extensive when considering medical procedures, hospital time, nursing time, follow up visits, and diagnostic concerns specific to VPS. Attention to details is paramount.

**Common Procedural Terminology Codes (CPT)**

Procedure codes are identified for specific diagnostic services such as computer tomography (CT) scans, magnetic resonance imaging and lumbar spinal punctures (Table 3). There are additional codes for shunt treatments such as shunt and catheter implantation, replacement and removal. There are also adjunctive shunt services for use of neuroendoscopic techniques. Shunt treatment codes are located in Table 4. Nurse Life Care Planners are encouraged to research the specific shunt a patient has and clarify specifics with that manufacturer.

### Table 2. Shunt related Diagnosis Codes

<table>
<thead>
<tr>
<th>ICD-10-CM</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>T85.01</td>
<td>Breakdown (mechanical) of ventricular intracranial (communicating) shunt</td>
</tr>
<tr>
<td>T85.01XA</td>
<td>Initial encounter</td>
</tr>
<tr>
<td>T85.01XD</td>
<td>Subsequent encounter</td>
</tr>
<tr>
<td>T85.01XS</td>
<td>Sequela</td>
</tr>
<tr>
<td>T85.02</td>
<td>Displacement of ventricular intracranial (communicating) shunt</td>
</tr>
<tr>
<td>T85.02XA</td>
<td>Initial encounter</td>
</tr>
<tr>
<td>T85.02XD</td>
<td>Subsequent encounter</td>
</tr>
<tr>
<td>T85.02XS</td>
<td>Sequela</td>
</tr>
<tr>
<td>T85.03</td>
<td>Leakage of ventricular intracranial (communicating) shunt</td>
</tr>
<tr>
<td>T85.03XA</td>
<td>Initial encounter</td>
</tr>
<tr>
<td>T85.03XD</td>
<td>Subsequent encounter</td>
</tr>
<tr>
<td>T85.03XS</td>
<td>Sequela</td>
</tr>
<tr>
<td>T85.09</td>
<td>Other mechanical complication of ventricular intracranial (communicating) shunt</td>
</tr>
<tr>
<td>T85.09XA</td>
<td>Initial encounter</td>
</tr>
<tr>
<td>T85.09XD</td>
<td>Subsequent encounter</td>
</tr>
<tr>
<td>T85.09XS</td>
<td>Sequela</td>
</tr>
</tbody>
</table>

### Table 3. Ventriculoperitoneal Shunt Common Procedural Terminology (CPT) Codes: Diagnostic Services

<table>
<thead>
<tr>
<th>Procedure</th>
<th>CPT Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>70450</td>
<td>CT, head or brain, without contrast</td>
</tr>
<tr>
<td></td>
<td>70460</td>
<td>CT, head or brain, with contrast</td>
</tr>
<tr>
<td></td>
<td>70470</td>
<td>CT, head or brain, with and without contrast</td>
</tr>
<tr>
<td>MRI</td>
<td>70551</td>
<td>MRI, brain, without contrast</td>
</tr>
<tr>
<td></td>
<td>70552</td>
<td>MRI, brain, with contrast</td>
</tr>
<tr>
<td></td>
<td>70553</td>
<td>MRI, brain, with and without contrast</td>
</tr>
<tr>
<td>Spinal Puncture</td>
<td>62270</td>
<td>Spinal puncture, lumbar, diagnostic</td>
</tr>
<tr>
<td></td>
<td>62272</td>
<td>Spinal puncture, therapeutic, for drainage of CSF</td>
</tr>
</tbody>
</table>

### Table 4. Ventriculoperitoneal Shunt Common Procedural Terminology (CPT) Codes: Treatment

<table>
<thead>
<tr>
<th>Procedure</th>
<th>CPT Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shunt and Catheter Implantation and Replacement</td>
<td>61107</td>
<td>Twist Drill, Burr Hole(s), or Trephine Procedures on the Skull, Meninges, and Brain.</td>
</tr>
<tr>
<td></td>
<td>62220</td>
<td>Creation of shunt; ventriculo-atrial, -jugular, -auricular.</td>
</tr>
<tr>
<td></td>
<td>62223</td>
<td>Creation of shunt; ventriculo-peritoneal, -pleural, other terminus.</td>
</tr>
<tr>
<td></td>
<td>62225</td>
<td>Shunt system or external drainage. Use in addition to code for primary procedure.</td>
</tr>
<tr>
<td></td>
<td>62230</td>
<td>Replacement or revisions of CSF shunt, obstructed valve or distal catheter in shunt system.</td>
</tr>
<tr>
<td></td>
<td>62258</td>
<td>Removal of complete CSF shunt system with replacement.</td>
</tr>
<tr>
<td>Adjunctive Shunt Services</td>
<td>+62160</td>
<td>Neuroendoscopy, intracranial, for placement or replacement of ventricular catheter and attachment to shunt system or external drainage. **Can only be used in conjunction with primary procedure codes. **</td>
</tr>
<tr>
<td>Shunt Removal</td>
<td>62256</td>
<td>Removal of complete CSF shunt system without replacement.</td>
</tr>
<tr>
<td>Reprogramming</td>
<td>62252</td>
<td>Programming of programmable cerebrospinal shunt</td>
</tr>
</tbody>
</table>
Conclusion
Ventriculoperitoneal shunts are a vital component of neurosurgical care with significant risk of complications. Costs and care needs are highly variable and usually complex. When evaluating clients with medical conditions requiring either placement, or revision of VPS, Nurse Life Care Planners need to understand the specific medical condition that is being treated. They must also identify the specific location of proximal and distal VPS placement to plan and code appropriately. Cost inclusions must account for immediate and ongoing diagnostic tests, possibility for additional treatments, future surgical procedures and need for recurrent follow up and specialty care. Neurosurgeon specific recommendations and ongoing dialogue with specialists and manufacturers insure diagnostic accuracy and clinical appropriateness. Integration of recent literature provides a foundation to build upon a patient’s anticipated life expectancy and maximize patient outcomes.

Kirsten Turkington, DNP, APRN, FNP-C, CNLCP
is the owner of North Scottsdale Health, PLLC, a primary care clinical practice in Scottsdale, Arizona and a faculty member at Grand Canyon University's Graduate and Doctoral Nursing programs. Dr. Turkington is a certified Nurse Life Care Planner with over 25 years of clinical experience. She can be contacted at Kirsten.Turkington@Outlook.com.

References


Dale Berry CP FAAOP LP
Dale Berry is an internationally recognized expert in prosthetic care with over 35-years of clinical care experience. He is also a published author and professional motivational speaker. Dale recently retired as Vice President of Clinical Operations of the largest provider of prosthetics in the nation with over 800 prosthetic clinics serving over 20,000 individuals with limb loss per year.

Nathan Copeland
Nathan Copeland was 18 years old when a car accident caused his quadriplegia in 2004. This catastrophic event often left him feeling like he would no longer be able to accomplish much with his life. Years later when presented the opportunity to help shape future technologies that could eventually benefit people in similar situations, he couldn’t refuse. For the last 5 years Nathan has participated in a brain-computer interface study through the University of Pittsburgh. Using microelectrode arrays implanted in his motor and sensory cortices he is able to control a robotic arm and receive sensations back from it.

Doreen Casuto BSN, RN, MRA, CRRN, CCM, CLCP, CNLCP
Doreen Casuto is the President and Founder of Rehabilitation Care Coordination, the first nurse life care planning & long-term case management company in San Diego. Doreen received her B.S. in Nursing from American University in 1970 & her Masters in Rehabilitation Administration from the University of San Francisco in 1984. After working as a rehabilitation nurse in Columbus, Ohio, coordinating a federal grant training nurses in rehabilitation and establishing an acute spinal cord injury and rehabilitation unit in Indianapolis, she came to San Diego in 1978 as the director of Physical Rehab Nursing at Grossmont Hospital. Upon leaving Grossmont in 1989 she founded Rehabilitation Care Coordination in San Diego, which has now grown to 16 employees. Her work has earned her numerous accolades including the Sharp Hospital Victory of Spirit Award in 2018 for the companies work for individuals with disabilities. She is also adjunct faculty at San Diego State University’s School of Nursing.

Shirley Daugherty RN, BSN, CNLCP, MSCC
Shirley Daugherty is a Registered Nurse, Certified Nurse Life Care Planner (CNLCP®) and Medicare Set-Aside Allocator (MSCC) with Daugherty & Associates, LLC. Ms. Daugherty is a member of the American Association of Nurse Life Care Planners.
Ms. Daugherty graduated with an Associate Degree in Nursing (ADN) in 1994 from Indiana State University. She obtained her Bachelor of Science in Nursing (BSN) degree from the University of Phoenix in 2012. Ms. Daugherty is currently enrolled in the Family Nurse Practitioner Program (FNP) at Indiana Wesleyan University, with an expected graduation of October 2021.

Ms. Daugherty has worked in long term care as a staff nurse and in management. She began a nurse consulting business (Daugherty & Associates, LLC) in 2004 focusing on long term care consultation. In 2007, she began the transition into legal nurse consulting, Nurse Life Care Planning and Medicare Set-Aside consultation. Ms. Daugherty is very active within the American Association of Nurse Life Care Planners (AANLCP) and is the past Secretary of the Executive Board. She is currently serving as the Secretary on the Certified Nurse Life Care Planner Certification Board with focus on seeking The Accreditation Board for Specialty Nursing Certification (ABSNC) for Nurse Life Care Planners.

Brad Dexter, DPT
Brad received his doctorate in Physical Therapy from UNMC and joined QLI in 2011 where he is currently the Coordinator of Therapy Services. The combination of his extensive expertise in orthopedic complications as well as his depth of knowledge on brain injury and spinal cord injury make Brad a valuable member of the QLI therapy team. Within QLI’s post-hospital rehabilitation program, Brad specializes in rehabilitation technology specific to gait and balance issues. He is a natural teacher and presents nationally educating professionals and family members on innovative rehab technology.

Heidi L. Fawber, M.Ed, LPC, CRC, CCM, CLCP, FIALCP
Heidi Fawber is a licensed professional counselor and rehabilitation consultant in private practice who has worked in the rehabilitation field since 1978. She initially provided catastrophic case management services and subsequently began to specialize in traumatic brain injury rehabilitation. In the past, she helped to develop a vocational and community re-entry program for persons with traumatic brain injury in Pittsburgh, PA. Later, at HealthSouth Harmarville Rehabilitation Hospital, she developed a mild brain injury clinic and later became the clinical director of the brain injury program. Ms. Fawber is a certified Life Care Planner and a Fellow in Life Care Planning (The College of Life Care Planning Excellence) who has been developing life care plan over the past 25 years. She has served as a consultant for the Brain Injury Association of Pennsylvania and has consulted as a Pre-Enrollment Assistance Coordinator for the Department of Health Head Injury Program. She continues to provide case management services on both adult and pediatric cases and maintains certifications in Case Management, Rehabilitation Counseling, and Life Care Planning.

Liz Holakiewicz BSN, RN, CCM, CNLCP
Liz has been a life care planner since the mid 1980’s and a CNLCP since 2000. She served on the first certification board for our organization and was published in the first core curriculum on critical thinking and the nursing process. Liz’s background includes case management, home health and critical care nursing. She is a California girl, born and raised in Orange County and now a local San Diegan. She has a small life care planning practice here in San Diego. She loves art, reading, travel and gardening.

Sherry Latham BSN, RN CLNC CLCP MSCC CNLCP
Ms. Latham is an experienced Certified Life Planner and Certified Nurse Life Care Planner with a demonstrated history of over sixteen years of working in the legal services industry and over thirty years as a nurse. Her legal expertise in life care planning as an expert witness has been provided nationally for catastrophic injuries of all types. Her skill set in development of life care plans, collaboration with healthcare providers, and her strong
ability to convey the needs of the injured during deposition and trial have been provided in State and Federal venues across the nation. Ms. Latham contributes to the field of life care planning through leadership positions, committee contribution, presentations, research data specific to the field of life care planning and contributing author of articles in the Journal of Life Care Planning and American Association of Legal Nurse Consulting. She has presented at local, state, national and international conferences about life care planning and ethics. Ms. Latham served as a Board member for the ICHCC CLCP of Commissioners from 2007-2019. She served as Chair of the International Commission on Health Care Certification CLCP Board of Commissioners, as well as the Executive Board of the ICHCC from 2012-2019. Ms. Latham serves as Adjunct Faculty for Capital Law Life Care Planning Program since 2018, which is one of only three pre-approved educational programs for the Certified Life Care Planning Certification, where she co-authored the life care planning curriculum. Ms. Latham was designated a Fellow of International Academy of Life Care Planners in 2019.

Erin OConnell MSN, MBA, RN, CNL, CNLCP®, CCM, MSCC
Erin OConnell was the AANLCP President from August 2018-December 2019 which provided her the opportunity to meet and work with an excellent and encouraging group of individuals. She has worked in the nursing field for over a decade. Her clinical experience is in a multitude of nursing areas including the ICU, Telemetry, ER, Long-term Care, Rehabilitation, Same Day/PACU, and as an adjunct college instructor. Her career has afforded her many diverse experiences and opportunities which have deepened her appreciation and respect for the field of Nurse Life Care Planning.

Dr. Marcel Ponton
Dr. Marcel Ponton is an Associate Clinical Professor in the Department of Psychiatry and Biobehavioral Sciences at UCLA. Currently, he serves at Olive View Medical Center where he trains pre-doctoral and post-doctoral students. He is the author of multiple peer-reviewed articles and the co-author of two books in the area of cross-cultural neuropsychological assessment. He is a Fellow of the National Academy of Neuropsychology and the Founding President of the Hispanic Neuropsychological Society. He has been working in the field of head injury assessment and treatment for the past 30 years. He is the Clinical Director of Persona Neurobehavior Group in Pasadena, where he treats patients and consults with multiple rehabilitation hospitals in the area.

Robert Simon
Along with his twin brother (Brad), Robert Simon is partner at the Simon Law Group - home of the Justice Team. Mr. Simon’s peers have voted and named him the “Trial Lawyer of the Year” in several jurisdictions within California. He and his firm are recognized for trying and handling the appeals of dozens of notable and high-profile cases each year, such as Bermudez and Pebley. Known to be at the forefront of innovation inside and outside of the courtroom, Mr. Simon is taking the legal industry to the next level as co-founder of Justice HQ: an exclusive membership for attorneys.
LOOKING AHEAD

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