

# Basic Science Of Closed Incision Negative Pressure Management

By: Wayne Lee, MD

Readmission rates—a metric that now has implications for both quality and cost—is now the standard for hospitals, clinicians, and policy makers.<sup>1</sup> The reason readmission rates became a quality standard was due to section 501(c) of the Deficit Reduction Act of 2005, which resulted in the Inpatient Prospective Payment System (IPPS). Hospital-Acquired Conditions (HAC) are included in (IPPS) and consist of 14 categories. Four out of the 14 categories are related to surgical site infection. In 2015, section 308 of the Patient Protection and Affordable Care Act established the Hospital–Acquired Condition Program to provide an incentive for hospitals to reduce HAC.<sup>2</sup>

Surgical site infections (SSIs) are classified as being either incisional or organ/space. Incisional is sub-classified as superficial or deep. Superficial incisional site infection is an infection that occurs in the first 30 days after the operation and the infection involves only skin or subcutaneous tissue of the incision and at least one of the following: (a) purulent drainage, (b) organisms isolated, (c) one of the signs and symptoms of infection, (d) diagnosis of infection by the surgeon.<sup>3</sup> Surgical wound refers to a wound created when an incision is made by a scalpel and then closed in the operating room by various methods, and resulting in close approximation to the skin edges. It is common practice to cover such wounds with dressings. The dressing may act as a physical barrier to protect the wound from contamination until the wound becomes impermeable to microorganisms.<sup>4</sup> SSI risk depends upon a number of patient factors including preexisting medical conditions, amount and

type of resident skin bacteria, perioperative glucose levels, core body temperature fluctuations, and preoperative, intraoperative and postoperative care. Therefore, it is difficult to predict which wounds will become infected.<sup>6</sup>

In addition to the above-listed modalities, several studies have shown optimized post-surgical outcomes with the use of negative pressure therapy over closed incision (ciNPWT) compared to conventional wound dressings<sup>7-14</sup> by (1) acting as a barrier to external contamination, (2) holding the incision edges together, thus decreasing wound dehiscent forces, (3) removing fluids and infectious material from the incision site and (4) improving the properties of the surgical wound.

### Barrier to External Contamination

The primary source of infection for most surgical site infections is the patient's endogenous microorganisms.<sup>15, 16</sup> Patients with history of diabetes mellitus, chronic obstructive pulmonary disease, long-term steroid usage, and repeat hospitalizations tend to be more heavily colonized with bacteria. Providing a protective barrier helps to reduce the external bioburden to the surgical wound.<sup>5</sup> Closed incision negative pressure wound therapy (ciNPWT) uses a clear barrier drape with adhesive which provides a barrier to external sources of infection. To test efficacy of the barrier drape, an *in vitro* viral penetration test (VPT)<sup>1,7</sup> was used. VPT uses a suspension of virus bacteriophage phiX174 to determine if the bacteriophage can penetrate across the proposed barrier. The VPT is the industry standard for testing of the barrier properties of surgical gowns and drapes.

### Removal of Fluid

When a surgical wound is closed, there is a resultant area of dead space. This dead space is filled with fluid which is called a seroma. Pachowsky M,<sup>19</sup> et al., in a small RCT of hip arthroplasty patients, showed a significant reduction of seromas in the surgical wound in patients treated with ciNPWT compared to standard dressings. Ultrasound was taken before surgery and then at 5 and 10 days postop. The study found a reduction of seroma volume in closed incision negative pressure dressings versus standard of care. Stannard JP,<sup>9</sup> et al. showed a reduction of drainage in patients following high-energy trauma when

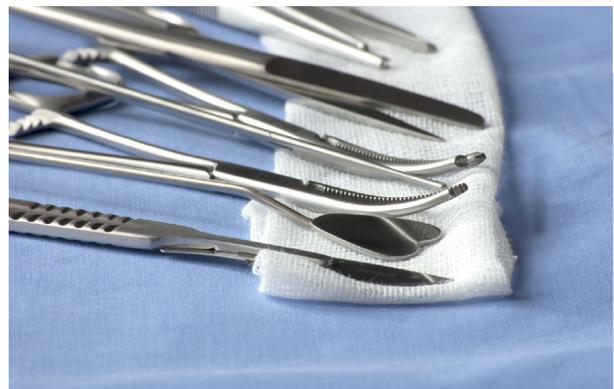
ciNPWT was used compared to standard dressings. Kilpadi DV,<sup>20</sup> et al. used a porcine animal model which created a surgical dead space. The wounds were closed and standard dressings versus closed negative pressure dressings were used. After four days of therapy, there was a 63% reduction of hematoma/seroma in closed incision negative pressure therapy. Their conclusion was closed incision negative pressure therapy significantly decreased hematoma/seroma levels, although it should be noted that not all incision management systems are indicated for hematoma/seroma management.

### Impact on Incision Healing

Wound healing has three phases: inflammation, proliferation and remodeling. It is now known that microRNAs play a role in gene expression and wound healing.<sup>22</sup> D.V. Kilpadi et al showed in a comparative porcine model that, after 5 days of closed incision negative pressure wound therapy compared to standard of care dressings, the resulting ciNPWT incisions had significantly improved mechanical properties (strain energy density, peak strain) and a narrower scar/healed area in the deep dermis on day 40 compared to standard of care incisions. These results were associated with a decreased expression of genes such as those associated with inflammation, hypoxia and scarring.<sup>23</sup>

### Summary

Surgical site infection is a multifactorial event that has significant impact on the patient, the hospital, the national economy and the world economy.<sup>24</sup> There are many modalities that have been found to be effective in decreasing the rate of surgical site infections. Closed incision negative pressure wound therapy (ciNPWT) Negative pressure therapy over closed incision has been found by several authors to improve post-surgical outcomes compared to standard dressings, by providing biomechanical properties that can increase the facilitate incision closure, remove incision fluid and cover and protect the incision.<sup>9, 20, 19, 21, 17</sup>





**Wayne Lee, MD**

Dr. Wayne Lee is a native of New Orleans, Louisiana and graduated from Meharry Medical College in Nashville, Tennessee. He completed his general surgery internship at Howard University Hospital in Washington, DC. He also completed his limb lengthening and trauma management fellowship in Italy. He is currently the Medical Director at Hill Country Surgery & Sports Medicine in San Antonio, Texas.

## References

1. CMS.gov. <https://www.cms.gov/medicare/medicare-fee-for-service-payment/hospitalacquired>
2. <https://www.cdc/hicpac/sfs/table1-SSI.html>
3. Alicia J. Mangram, MD et al. Guideline for Prevention of Surgical Site Infection, 1999.
4. Scott RD. The Direct Medical Costs of Healthcare-Associated Infections in U.S. Hospitals and Benefits of Prevention. Atlanta (GA): Division of Healthcare Quality Promotion, National Center for Preparedness, Detection and Control of Infectious Diseases, Centers for Disease Control and Prevention, 2009.
5. Suzanne M. Pear, RN, Ph.D., CIC. Patient Risk Factors and Best Practices for Surgical Site Infection Prevention.
6. Global Guidelines on the Prevention of Surgical Site Infection, 2016.
7. De Vries, Fleur E. MD; Wallert, Elon D. BSc. et al. A systematic review and meta-analysis including GRADE qualification of the risk of surgical site infections after prophylactic negative-pressure wound therapy compared with conventional dressings in clean and contaminated surgery. *Medicine* (2016) 95:36.
8. Stannard JP, Volgas DA, Stewart R, et al. Negative pressure wound therapy after severe open fractures: A prospective randomized study. *J Orthop Trauma* 2009; 23: 552-557.
9. Stannard JP, Robinson JT, Anderson ER, et al. Negative pressure wound therapy to treat hematomas and surgical incisions following high-energy trauma. *J Trauma* 2006; 60:1301-1306.
10. Gillespie BM, Rickard CM, Thalib L, et al. Use of negative pressure wound dressings to prevent surgical site infection complications after primary hip arthroplasty: A pilot RCT. *Surg Innov* 2015; 22:488-495.
11. Howell RD, Hadley S, Strauss E, et al. Blister formation with negative pressure dressings after total knee arthroplasty. *Curr Ortho Pract* 2011; 22:176-179.
12. Masden D, Goldstein J, Endara M, et al. Negative pressure wound therapy for At-Risk Surgical Closures in patients with multiple comorbidities: A prospective randomized controlled study. *Ann Surg* 2012; 255:1043-1047.
13. Selvaggi F, Pellino G, Sciaudone G, et al. New advances in negative pressure wound therapy (NPWT) for surgical wounds of potential effects with Crohn's disease. *Surg Technol Int* 2014; 24:83-89.
14. Pellino G, Sciaudone G, Candilio G, et al. Preventative NPWT over closed incisions in general surgery: Does age matter? *Int. J. Surg* 2014; 12:S64-S68.
15. Cheadle WG. Risk factors for surgical site infections. *Surg Infect (Larchmt)* 2006; Suppl 1:S7-11.
16. Dohmen PN. Influence of skin flora and preventive measures on surgical site infection during cardiac surgery. *Surg Infect (Larchmt)* 2006; 7 Suppl 1:S13-17.
17. Lytle CD, Carney PG, Vohra S, Cyr WH, Bockstahler LE. Virus leakage through natural membrane condoms. *Sex Transm Dis.* 1990 Apr-June;17(2):58-62.
18. Shanmugam VK, Fernandez SJ, Evans KK. Postoperative wound dehiscence: Predictors and association. *Wound Repair and Regeneration* 23, 184-190.
19. Pachowsky M, Gusinde J, Klein A, et al. Negative pressure wound therapy to prevent seroma and treat surgical incisions after total hip arthroplasty. *Int Ortho* 2012; 36:719-722.
20. Kilpadi DV and Cunningham MR. *Wound Rep Regen* 2011; 588-596.
21. Apostolos P, Labanaris, Elias Polykandriotis, Raymund EH. The effect of vacuum-assisted closure on lymph vessels in chronic wounds. *JPRAS* 2009, 62:1068-1075.
22. Fatima Fahs, Xinling Bi, Fu-Shin Yu, Li Zhou, (2015). New insights into microRNAs in skin wound healing. *IUBMB Life*, 67 (2).
23. Kilpadi DV, Lessing C. Healed Porcine Incisions Previously Treated with a Surgical Incision Management System: Mechanical, Histomorphometric, and Gene Expression Properties.