

# Infections, Adhesions, Blood Clots, Poor Scar Formation

## The Confirmed Role of Lint Fiber

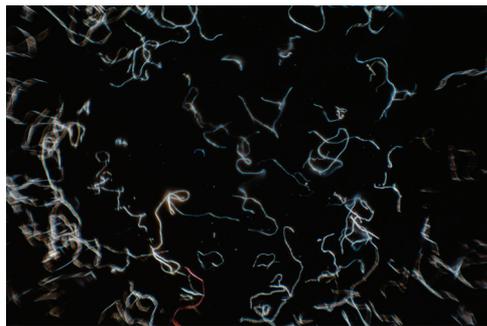
As elective surgeries begin to be scheduled after the Covid-19 shut down, Hospital, Ambulatory, and Interventional Radiology Surgical sites are preparing for patients. Before rooms are again scheduled one surgery on top of another, every effort must be made to ensure patient safety. It is the time to make certain every inch of your OR is scrubbed, disinfected and made safe.

We appropriately focus on eliminating environmental microbial contamination while reinforcing practices directed at reducing microbial introduction during invasive procedures. However, there are related culprits that have been proven time and time again over the last several decades to cause post-surgical complications and yet continue to be insufficiently addressed. These diminutive culprits can be transported on air currents increasing their presence with increasing traffic in the OR. They originate from items such as apparel, surgical towels, drapes, gauze, instrument liners and patient positioning aids. They land on surgical light fixtures, lopes and instruments, guidewires and catheters, and in the surgical wound. Depending on the type of surgery or other invasive procedure fiber contamination of the wound can cause or amplify existing post-surgical complications including:

- **Surgical site infections:** increased incidence, increased severity
- **Biofilm formation:** breast implant capsule contracture, orthopedic prosthetic implant chronic infections
- **Embolisms:** cardiac cerebral infarctions, pulmonary embolisms, limb loss, post-surgical psychopathological disturbances, & stroke, liver, spleen, kidney damage
- **Granulomatous peritonitis:** sterile, non-sterile
- **Chronic adhesions:** band formation, bowel obstruction, tubal factor infertility, chronic pain
- **Excessive inflammation:** vascular damage, synovitis
- **Poor wound healing:** delayed healing, pain, excessive scar volume with reduced strength, flexibility, dehiscence

- **Ophthalmic injury:** Toxic Anterior Segment Syndrome (TASS), sterile endophthalmitis, infectious endophthalmitis

Although each complication can have multiple causes, the role of cellulose fibers from cotton and wood pulp (paper) materials have not been taken seriously in several surgical Specialties and many facilities. Cellulose fibers themselves cause pathophysiological responses when present in various human tissues. These responses are amplified by the presence of chemicals, dyes, preservatives, softeners, fire retardants, water proofing agents, endotoxins and other agents and organics that are often present on individual fibers that may make up items in the surgical suite. If these coated fibers contaminate the wound, the substances can leach from the fibers over time potentially causing direct toxic damage and triggering an inflammatory immune response.



ABOVE: TAPE PULL DEMONSTRATES TYPICAL LINT PARTICLES FOUND ON A TYPICAL SPD BUNDLE

### Fiber-Associated Pathology Brief:

**Infection:** Although surgery has continued to implement increasingly advanced means of reducing microbial contamination during

surgery, some bacteria inevitably contaminate the surgical site. Studies have shown that particles in a wound significantly reduce the number of bacteria required to cause an infection. Presumably, the immune response focuses on the physically larger threats, initially ignoring the bacteria (immune distraction), allowing them to multiply. Additionally, lint and other particles can carry bacteria into the wound as they float on air currents from anywhere near the patient.

**Biofilms:** The physical presence of lint, fibers, and other particles can also provide shelter for bacteria to initiate biofilm formation. Multiple Case reports have highlighted the presence of particles associated with “micro-biofilms” on breast implants as one of the primary causes of capsular contraction as the body tries to wall off the subclinical infection to prevent access to the rest of the body. A similar pathological progression can result in delayed, recalcitrant infections following orthopedic prosthetic implants. Furthermore, chronic recurrences of infection due to the periodic dispersal of bacteria and biofilm fragments resulting in new colonies. Biofilms are also a source of spreading antibiotic resistance and increasing the presence of small colony variants (SCV), a newly appreciated threat from several pathogens.

**Embolisms:** Formation of thrombi around fibers and other particles in the blood stream is an attempt wall-off the invasion of a foreign entities. More layers of fibrin and “netted” red blood cells continue to increase the size of foreign body emboli until it reaches a size that can no longer pass through a narrowing or bifurcating blood vessel. A partial or full blocking of all or part of the blood flow causes ischemia and the potential for infarction of downstream tissues and organs. It is extremely important that our cardiovascular and interventional radiological centers are completely aware the consequences of lint fibers and debris in their procedure rooms.

**Granulomas:** Again we see lint fibers and particles as foci triggering the protective “walling-off” strategy to prevent escape of these perceived threats into the rest of the body. Macrophage white blood cells surround foreign object and merge their cell membranes forming a distinct “giant cell” microscopic formation. Many fibers or particles, in the abdominal cavity can result in granulomatous sterile or infectious peritonitis.

**Adhesions:** Adhesions can occur in any surgery, but are by far more prominent in abdominal procedures where greater than 90% of the patients develop adhesions. Most cause minimal discomfort and are absorbed by the body within a few months. Whether due to residual dead tissue, a leaky intestine, traumatic tissue damage, or to the entrapment of fibers, particulates or other foreign debris, chronic adhesions notably have a purpose for not dissolving. In the case of foreign debris, the threat has often already been enveloped with macrophage cells as granulomas. Adhesions then form to hold the invaders in place by attaching “anchors” to the closest organs and tissues. As the weeks and months pass, these chronic adhesions increase in size. They strengthen their fibrous bands connecting organs such as the intestines, bladder, liver, spleen, fallopian tubes, ovaries, or uterus to the omentum or to each other. Resection to relive intestinal obstruction or blockage is associated with a 10% mortality rate.

**Excessive inflammation:** In their efforts to defend the body from lint fibers and particles, neutrophil immune cells expel oxidative radicals and enzymes to “kill” the foreign bodies. Instead, they damage the surrounding tissues as collateral damage. As more neutrophils are recruited to the site utilizing the same ineffective technique, inflammation is amplified and the area affected expanded. If the amplified inflammation occurs in a synovial joint, the synovial membrane will likely be inflamed (synovitis). Inflammation, swelling, stiffness and pain becomes chronic if the fibers are left in the joint, ultimately resulting in cartilage damage and osteoarthritis.

It is important to note that cellulose lint fibers, which are bio-reactive themselves, often also contain various combinations of adhesives, fire-resistance chemicals, fluid resistance treatments, organic contamination, endotoxins, and bacteria; any and all of which may leach into the wound, exacerbating the inflammatory reaction to the presence of the lint alone.

**Poor wound healing:** Excessive inflammatory reactions can also result in delayed healing, increased risk of infection, pain, excessive scar volume that has reduced strength and flexibility, with the possibility of incomplete closure or dehiscence.

**Ophthalmic injury:** Toxic Anterior Segment Syndrome (TASS), sterile endophthalmitis, and infectious endophthalmitis can be caused by lint fibers and particulates . Each of these ophthalmic post-surgical complications has been associated with environmental debris contamination of the eye during surgery.

**A Case Study for us all to remember:** Three area hospitals experienced 24 cases of cellulose fiber foreign-body granulomatous reactions. Six patients suffered granulomatous peritonitis with one mortality. 22 additional surgeries were performed on these patients. An additional 400 days of hospitalization were required to address the complications associated with reactions to cellulose fibers from surgical drapes purchased by all three hospitals.

Reduce post-surgical complication risks for your patient by preventing surgical site contamination by lint fibers.



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