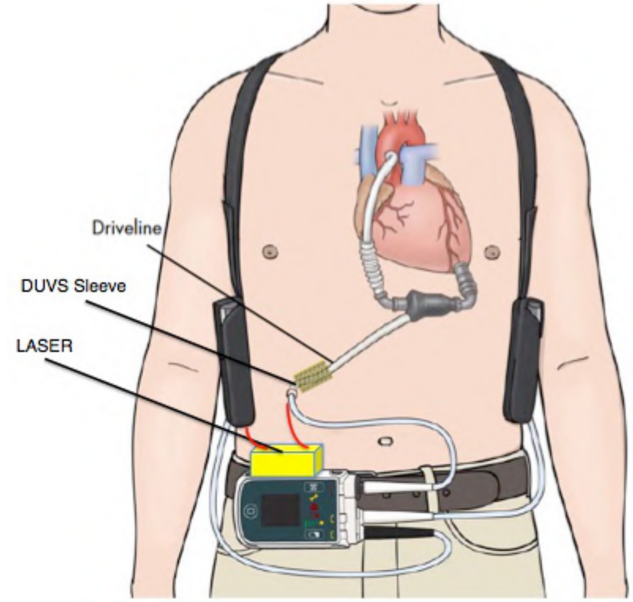
Fiber Optic Percutaneous Device Sterilizer

(DUVS – LVAD)

DUVS = Differential Ultraviolet Sterilization
LVAD = Left Ventricular Assist Device

Unmet Need

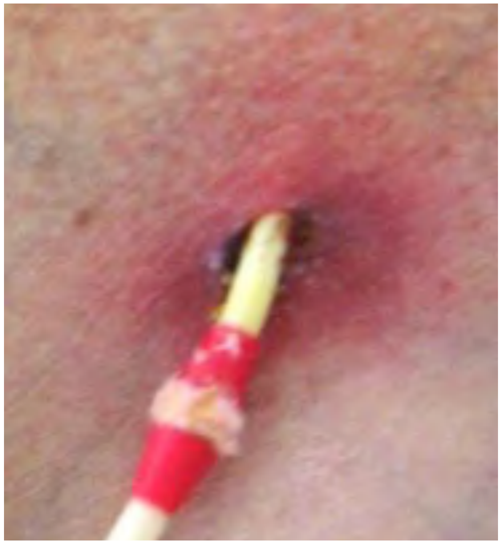


To eradicate percutaneous device infection through fiber optic transmission of UV light lethal to bacteria but not harmful to patients.

Percutaneous Device Infections

- Central or Arterial Line, IV, Swan-Ganz, T-tubes, Foley
- Pacing wires, ECMO, Wound Drains, Gastrostomy, Colostomy
- Fracture Fixation (2m), Implants, Valves, Joints, Grafts

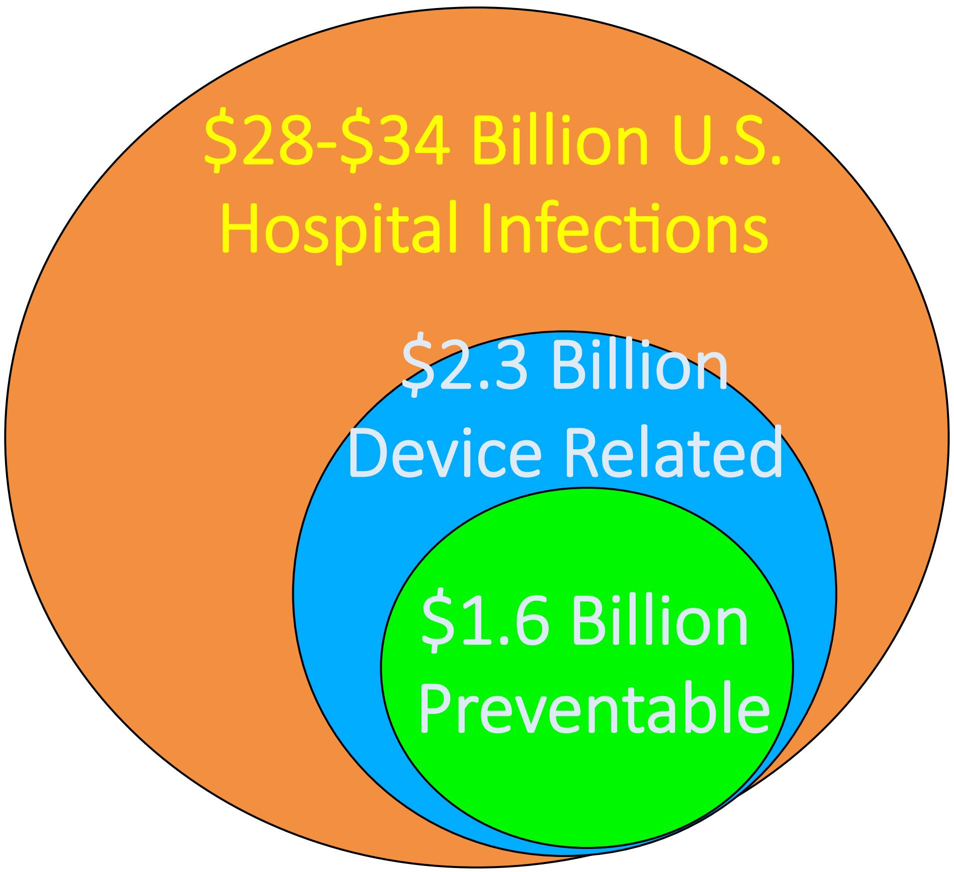
Tracheostomy



Chest Tube

Tunneled Dialysis Catheters (58%)

Addressable Infection Market



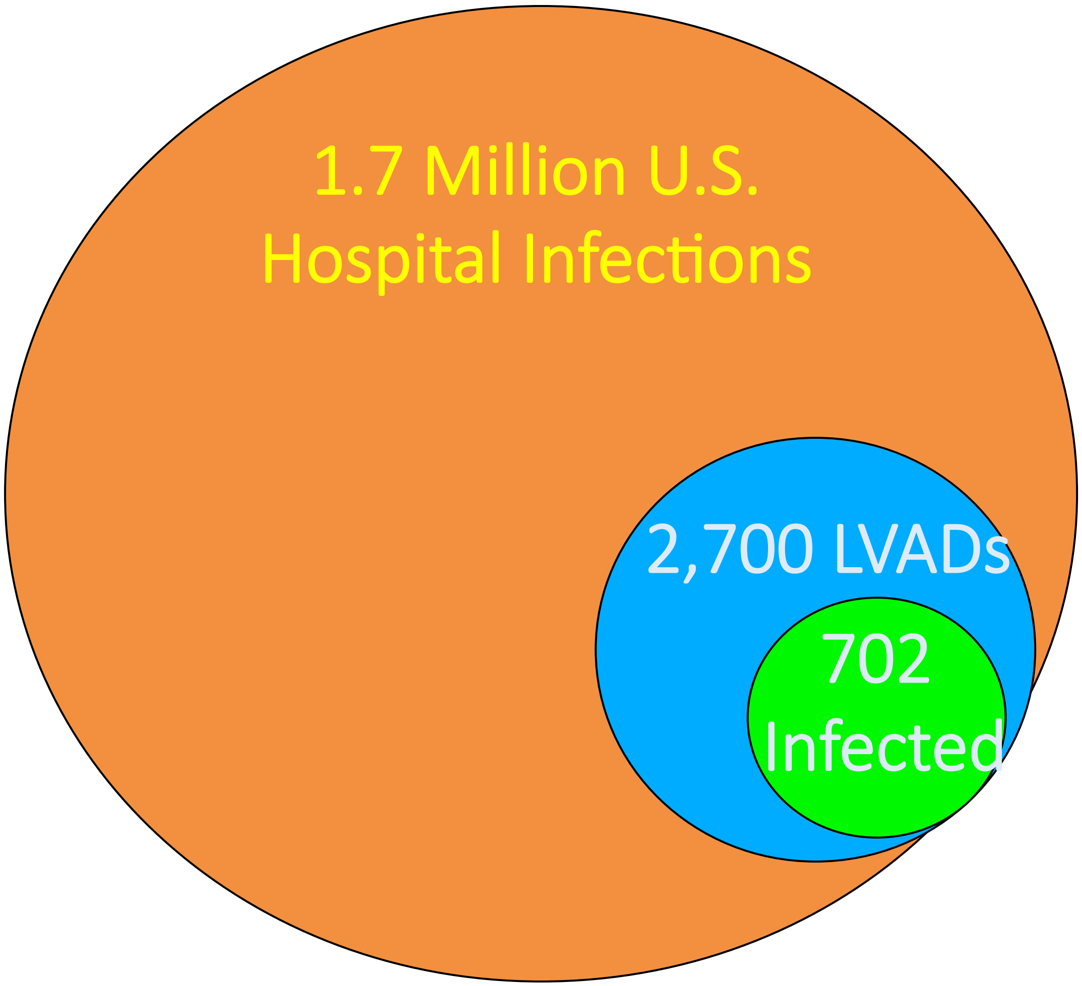
- 1.7 million U.S. nosocomial infections 2002.
- $28-$34 billion infection cost, U.S. 2007
- Central Line 92,011
  $0.7-$2.7b
- Foley 449,334 $0.4b
- Dialysis MRSA 2,300 x $20,000 = $46m

Market: 5 m CVL , 30 m Foley, 250,000 THD x $50

Scott RD. The Direct Medical Costs of Healthcare-Associated Infections in US Hospitals and the Benefits of Prevention, 2009. Atlanta: Division of Healthcare Quality Promotion, National Center for Preparedness, Detection, and Control of Infectious Diseases, Coordinating Center for Infectious Diseases, Center for Disease Control and Prevention; 2009.

Nissenson AR, Dylan ML, Griffiths RI, et al. Clinical and economic outcomes of *Staphylococcus aureus* septicemia in ESRD patients receiving hemodialysis. *Am J Kidney Dis* 2005; 46:301-308.

Addressable LVAD Market



- 2,700 LVADs 2015
- Device Cost $60-90k
- $162-243 million LVAD cost
- 20-26% Infected (702)
- Infection cost $30,000
- $16m infection cost
- $2,000 Device
- $5.4m DUVS market

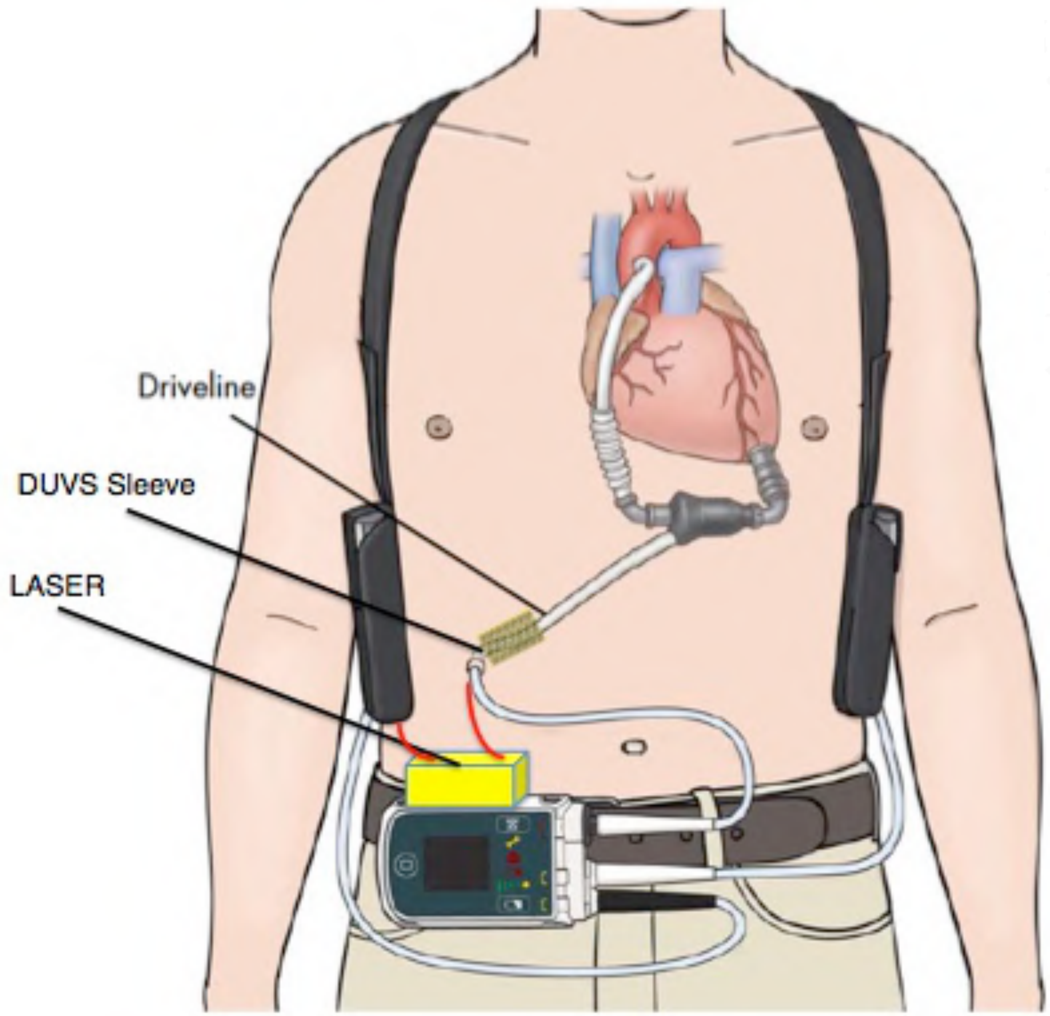
**Intermacs NIH trial*

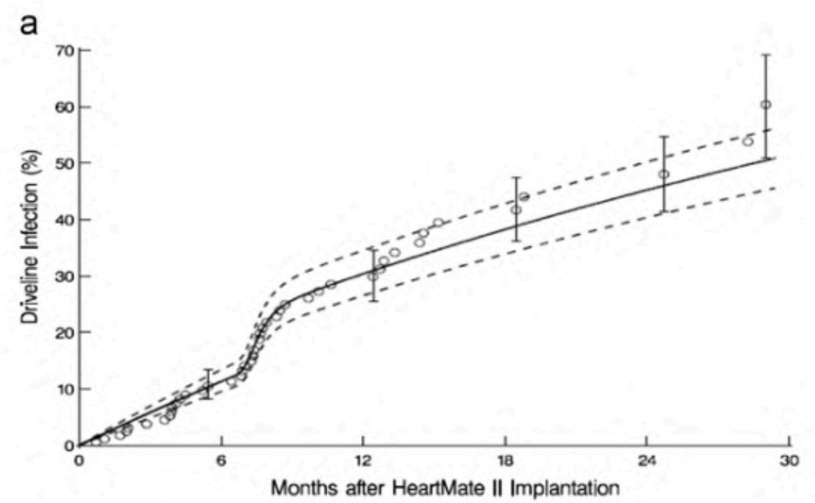
Immediate Focus

Driveline Infection

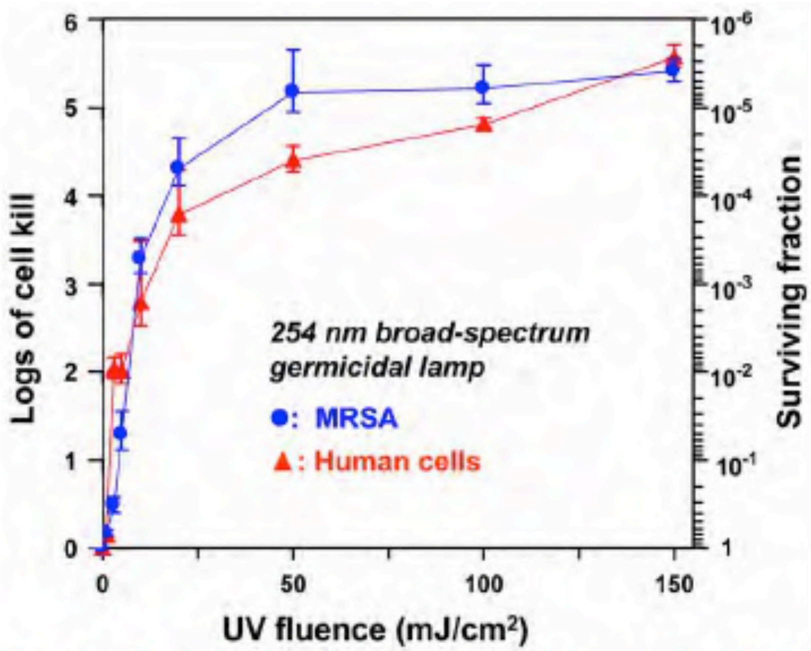
- “Achilles Heel” of LVAD reversal of multi-systems organ failure.
- Dramatic heart failure rescue becomes clinical, humanitarian, financial disaster.
- *High-visibility market for cost-effective, non-toxic sterilization implementation.*

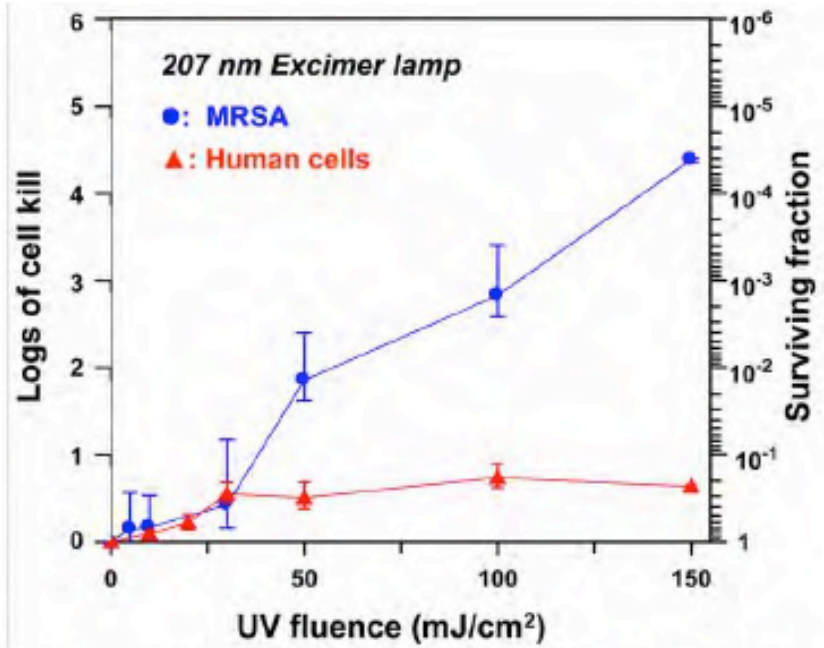
Envisioned Product





Underlying Technology

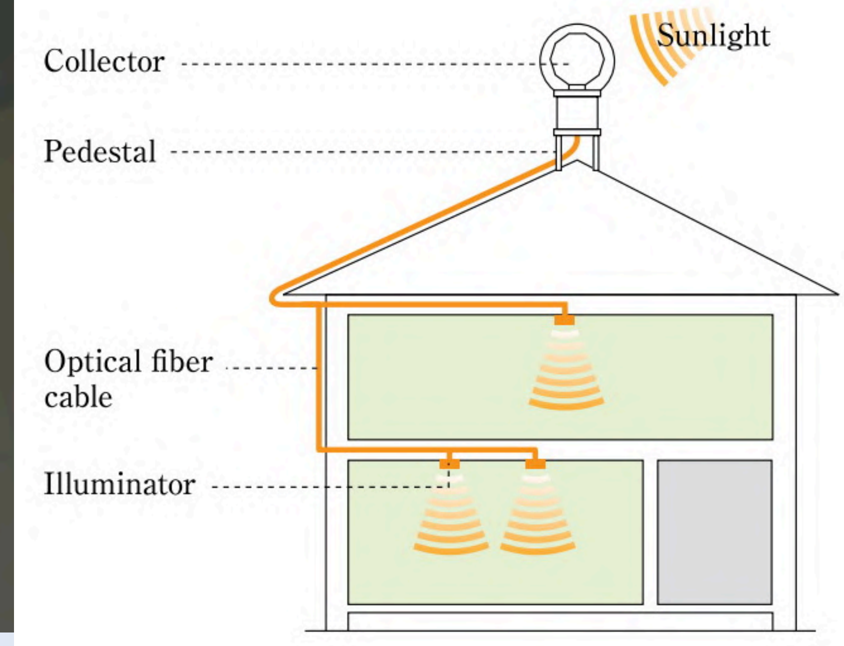


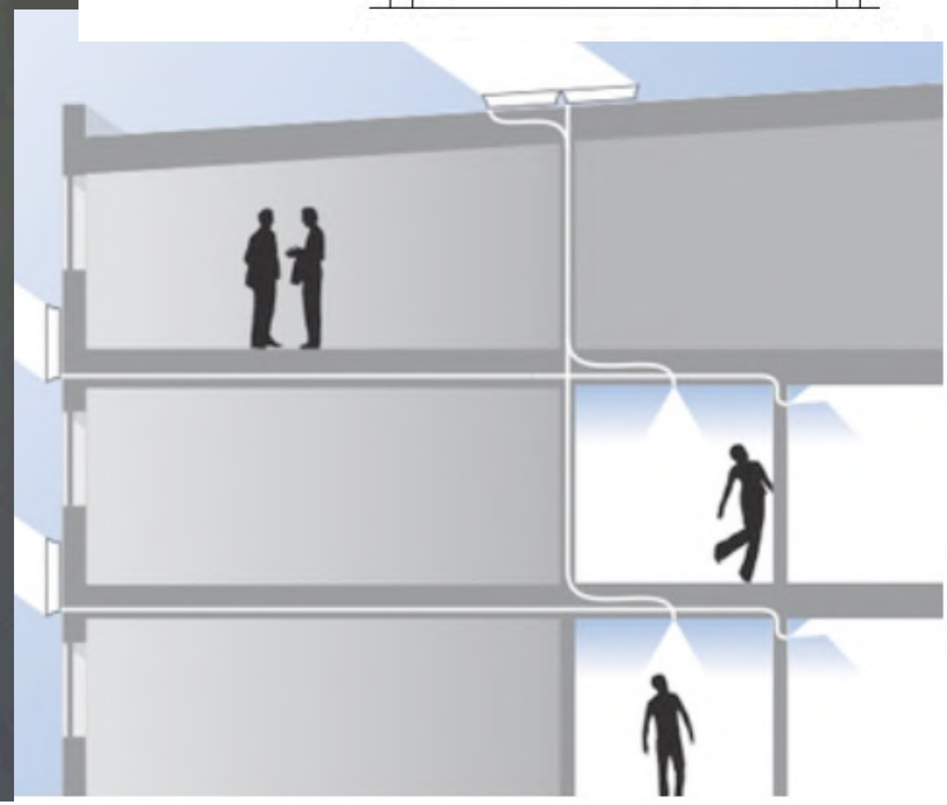


207-nm UV Light - A Promising Tool for Safe Low-Cost Reduction of Surgical Site Infections. I: *In Vitro* Studies

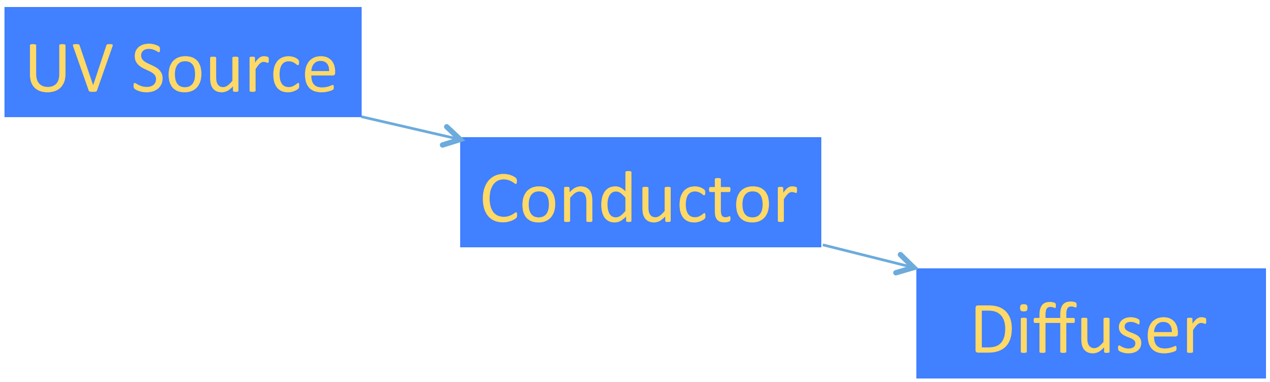
Manuela Buonanno[1], Gerhard Randers-Pehrson[1], Alan W. Bigelow[1], Sheetal Trivedi[2], Franklin D. Lowy[2], Henry M. Spotnitz[3], Scott M. Hammer[2], David J. Brenner[1]*

Fiber Optics

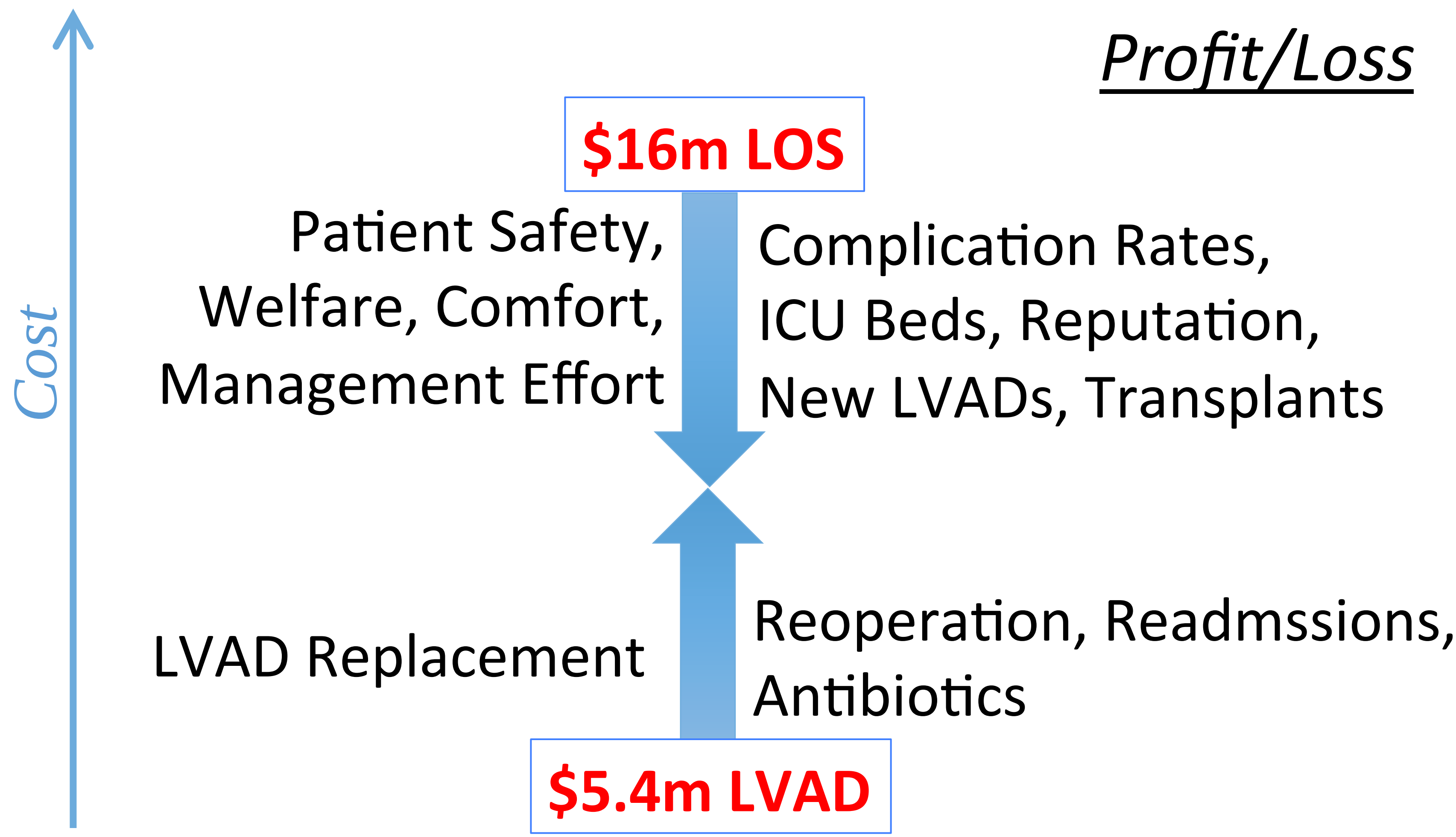




Concept



Stakeholder Interests



Better Results = More LVAD Sales and Profit

Competition

- Advancing Standard of Care – Failed to Date
- Bonded Antibacterials – Failed in LVADs
- LVADs/TAH in Development – Not Validated
- Alternate UV Implementation – Not Validated

LVAD Reimbursement

Topic	Description
Procedure	O.R. Implant
Coverage, Technology Assessments	CMS criteria: - FDA approved device - Bridge to Transplant – wait listed - Destination Therapy: no Transplant
CPT Code, Payment	33975, 33979; LVAD: $92,000; covered by Medicare, Insurance Companies
Facility Cost	Pump placement: $220,000 (+$35k infection) Readmission: $105,300 (infection and sepsis)
VAD Growth	2,348 LVADs in 2014; 15% increase/year

Disease State Analysis

- Glycoproteins, Adherence, Colonization
- Slime Layer, Biofilm, Migration
- Clinical Infection
- Inpatient: Antibiotic Rx until LVAD Removed or Replaced; ? Urgent Transplant.

- Outpatient Surveillance:
  - Dressing Protocols.
  - Clinic Visits.
  - Cultures.
  - Outpatient/Inpatient Rx

Intellectual Property Portfolio

- Invention Reports Filed.
- Patent Application in Preparation.
- Novel Design.
- Commercial UV Laser
- DUVS Licensed to USHIO

Milestones

- Prototype
- Technology Demonstration
  - UV Sterilization
  - No Harm to Animal Host
- Bacterial Resistance Evaluation
- Materials Degradation Assessment

Funding Options

- USHIO
  - Not Fiber Optic Specialists
  - Focused Elsewhere
  - Not LVAD Surgeons
  - Investing elsewhere
- NIH
  - Too Early
- Coulter Supported CUMC Team
  - Strong Motivation re LVAD
  - Talented Engineer/Scientists
  - Columbia IP

Our Team

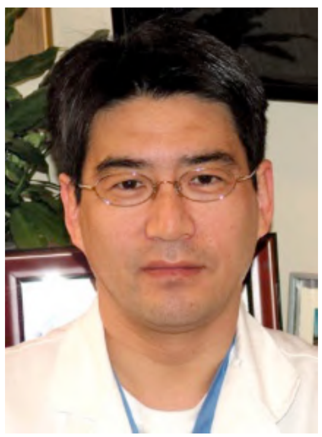
Henry M. Spotnitz
Clinical PI

Andreas H. Hielscher
Bioengineer PI

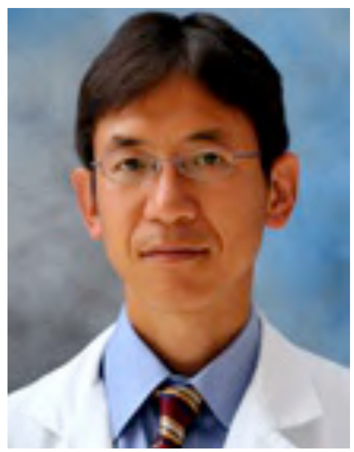
David J. Brenner
Radiation Biophysics

Alan W. Bigelow
Engineering/Physics

Gerhard Randers-Pehrsons
Engineering/Physics



Yoshifumi Naka
Clinical LVAD

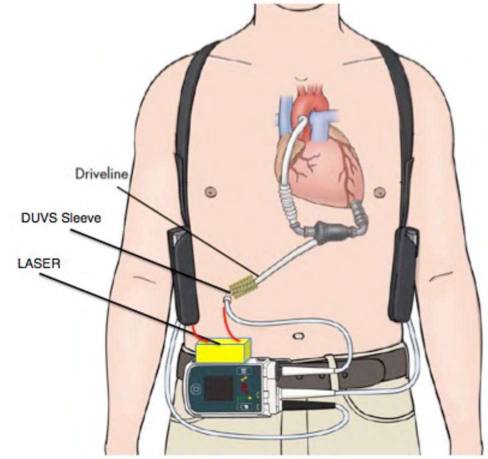


Hiroo Takayama
Clinical LVAD

Wanda Truong
Coordinator

Peter Golikov
Licensing

Summary



Eradication of Percutaneous Device Infection

- Investigators: Motivated, effective, innovative team will develop and test prototypes.
- Immediate Goal: Demonstrate cost-effective infection prevention through fiber optic transmission of UV light lethal to bacteria but not to patients.
- Long-Term Goal: Evolve across spectrum of implants.

Wallace H. Coulter Foundation

Cardiothoracic Surgery

RARAF

Columbia University Medical Center

THANK YOU!

Thoratec Corporation

NewYork-Presbyterian
The University Hospital of Columbia and Cornell

Department of Surgery CRC Clinical Research Core

USHIO
Lighting Edge Technologies

Discussion Slides

The critical payoff for investment in this project will be demonstration of the validity of infection prevention by fiber optic conduction of narrow spectrum, far ultraviolet light to the skin-prosthetic-bacterial interface.

Having proven this, extension of this technology across the spectrum of percutaneous medical devices would simply be a matter of finding conductive materials compatible with construction of these devices.

Continuous ultraviolet illumination of fluid containing catheters and cannulas is expected to eliminate bacterial growth on the outside of catheters and tubing and also on the inside - preventing colonization of infusions that can lead to septicemia [13].

In the case of urinary catheters, a thorn in the side of current health care improvement efforts [3, 4], it is conceivable that related urinary tract infections could be completely eliminated

Percutaneous Device Infections

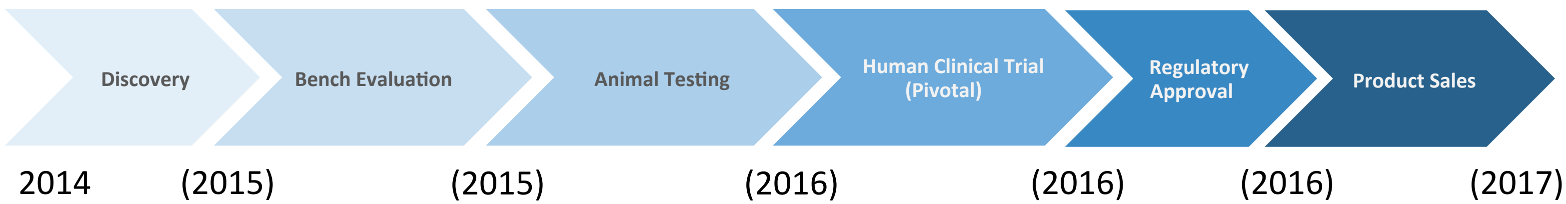
Table 1. The magnitude of the problem of device-associated infections.

Device	Estimated no. inserted in the United States per year	Rate of infection, %	Attributable mortality[a]
Bladder catheters[b]	>30,000,000	10–30	Low
Central venous catheters[b,c]	5,000,000	3–8	Moderate
Fracture fixation devices[b]	2,000,000	5–10	Low
Dental implants[d]	1,000,000	5–10	Low
Joint prostheses[b]	600,000	1–3	Low
Vascular grafts[b]	450,000	1–5	Moderate
Cardiac pacemakers[b,d]	300,000	1–7	Moderate
Mammary implants, in pairs[e]	130,000	1–2	Low
Mechanical heart valves[d]	85,000	1–3	High
Penile implants[b,d]	15,000	1–3	Low
Heart assist devices[d]	700	25–50	High

[a] Semiquantitative scale for attributable mortality: low, <5%; moderate, 5%–25%; high, >25%.
[b] Numbers estimated by analysis of market reports.
[c] Numbers estimated by review of the medical literature.
[d] Numbers estimated by personal communication with personnel from device manufacturing companies.
[e] Numbers estimated by review of data provided by medical associations.

Darouiche RO. Device-associated infections: a macroproblem that starts with microadherence. Clin Infect Dis. 2001;33:1567–72.

Go-To-Market Timeline/Regulatory



Stage	Pre-Clinical	Human Pilot	Clinical
Subject #s	100 (pigs)	25	2500
Cost	$1M	$2.5M	$25M

*Pending feedback from Licensing Officer

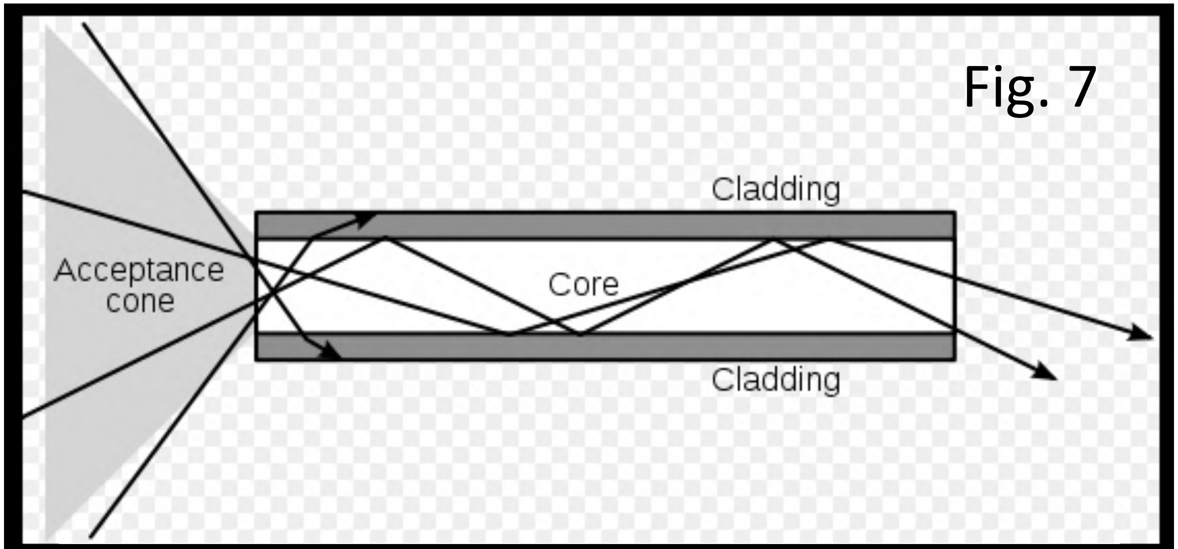
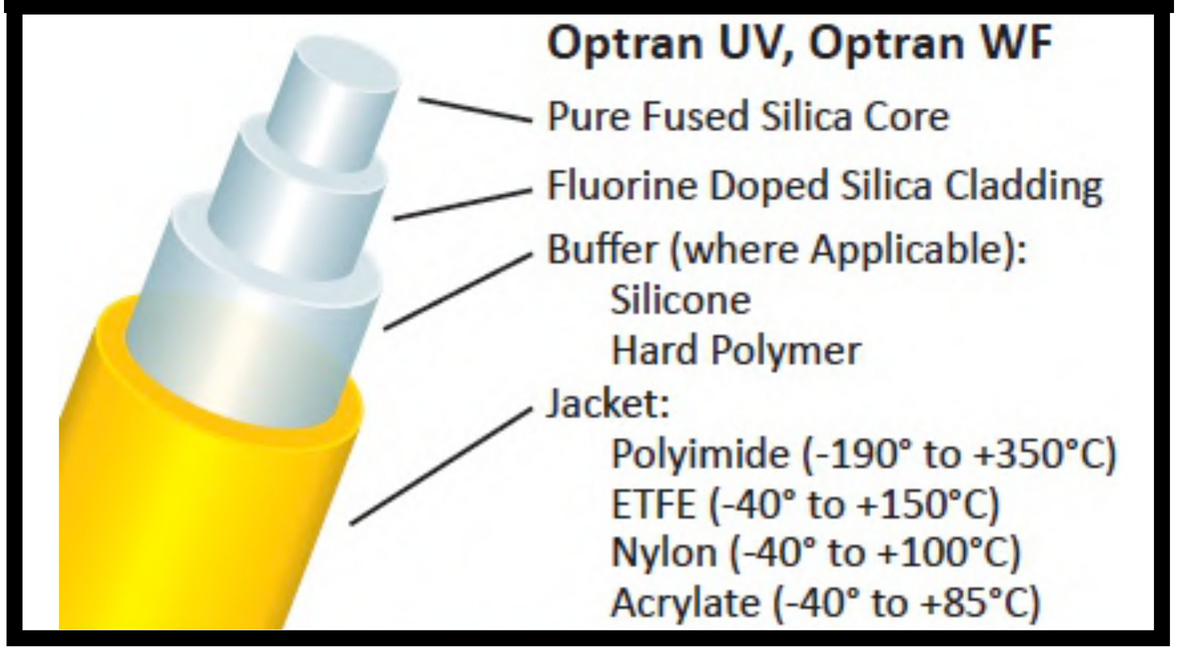
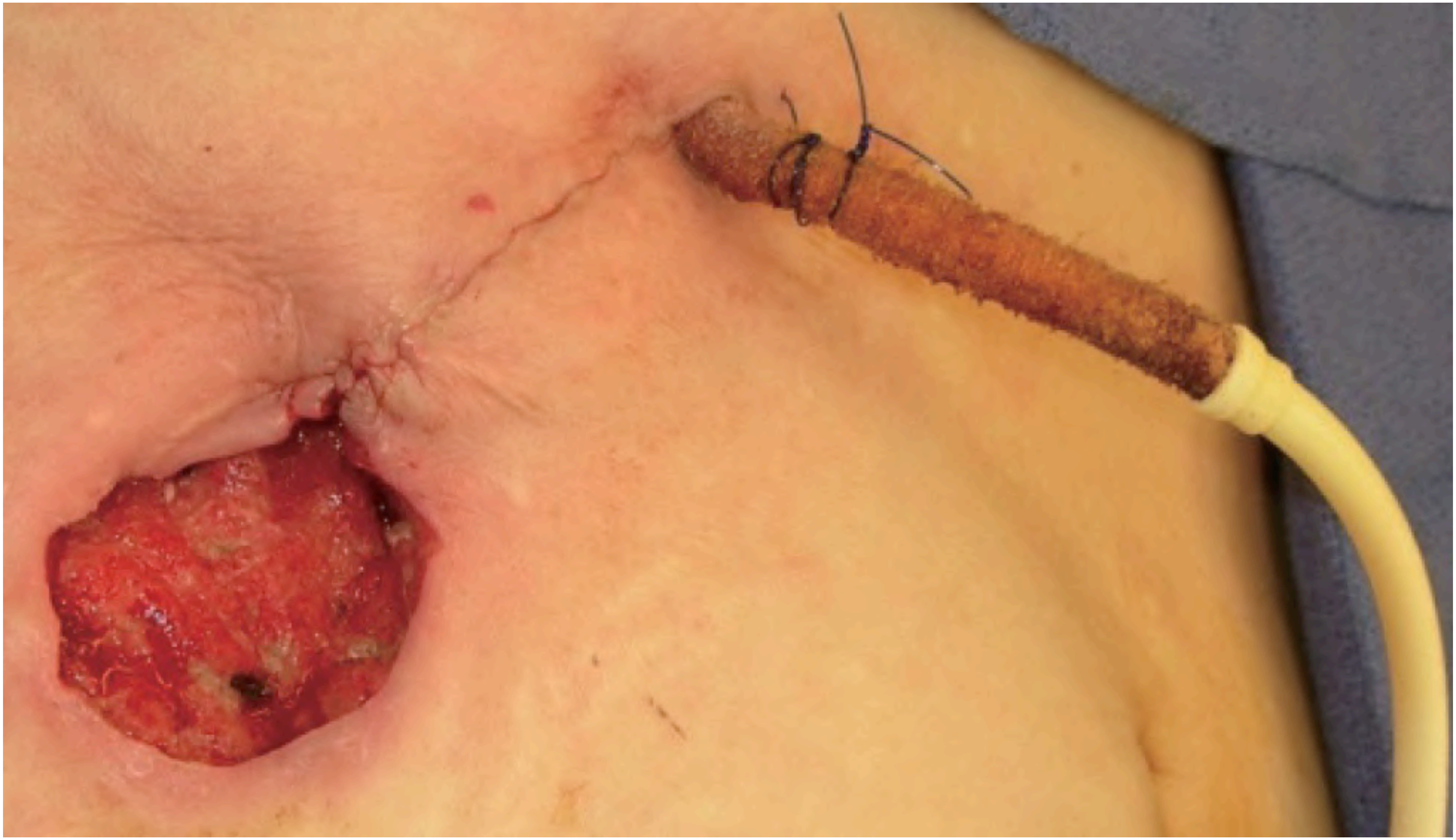
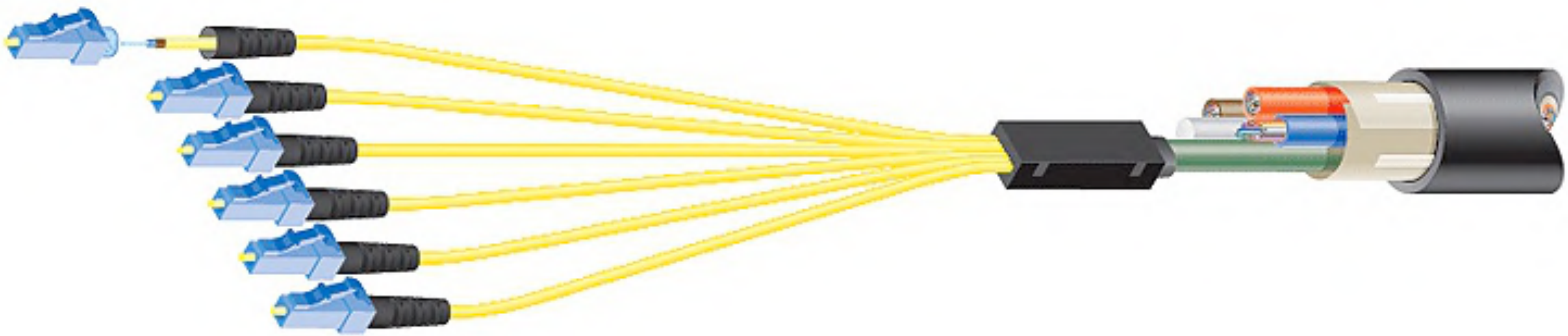
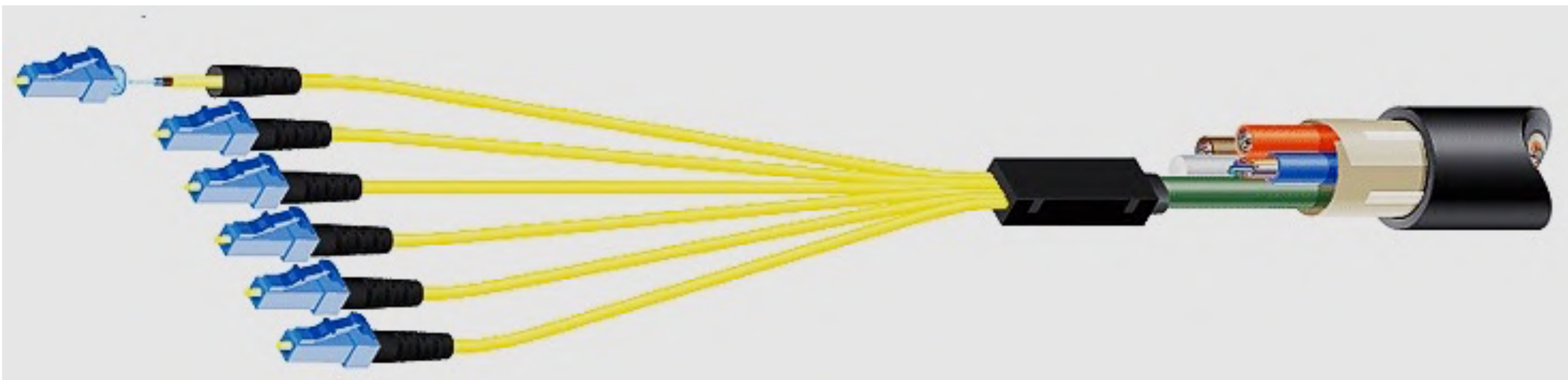

Cladding
Acceptance
cone
Core
Cladding

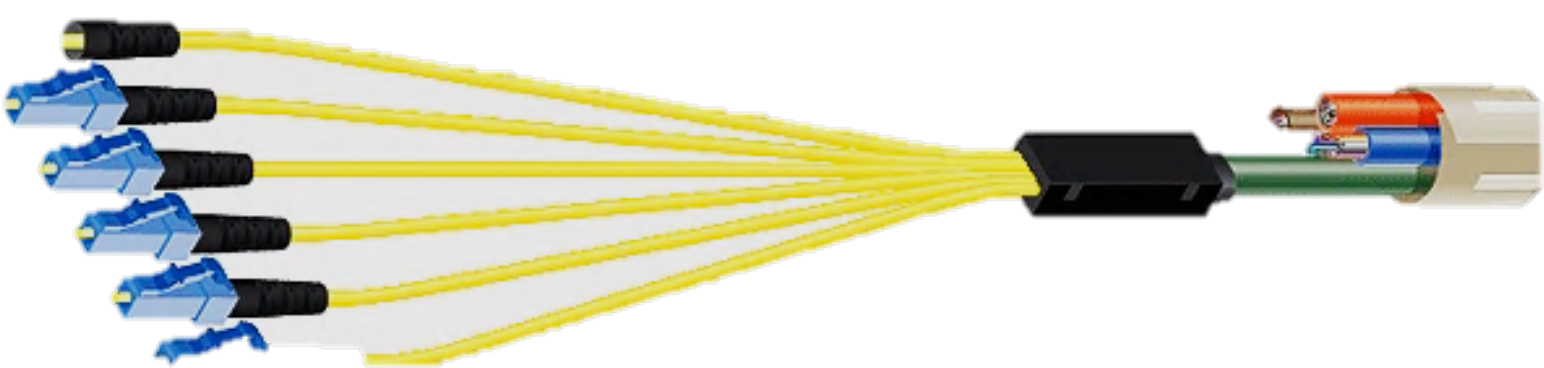
Fig. 7


Optran UV, Optran WF
Pure Fused Silica Core
Fluorine Doped Silica Cladding
Buffer (where Applicable):
Silicone
Hard Polymer
Jacket:
Polyimide (-190° to +350°C)
ETFE (-40° to +150°C)
Nylon (-40° to +100°C)
Acrylate (-40° to +85°C)









Risk & Benefits of Treatment Options

Treatment Category	Treatment Options	Benefits	Risks
Pharmacologic	Antibiotics	Infection suppression	Bacterial resistance, susceptibility to secondary infections
Surgical	Device Replacement	May eliminate infection	Risks of reoperation
	Antibiotics and device therapy	May eliminates infection	New infection can still occur, risks of reoperation

Disease State Analysis

Clinical outcomes: Long term antibiotic therapy is administered until the LVAD is removed or the infection progresses to the point where the device must be replaced.

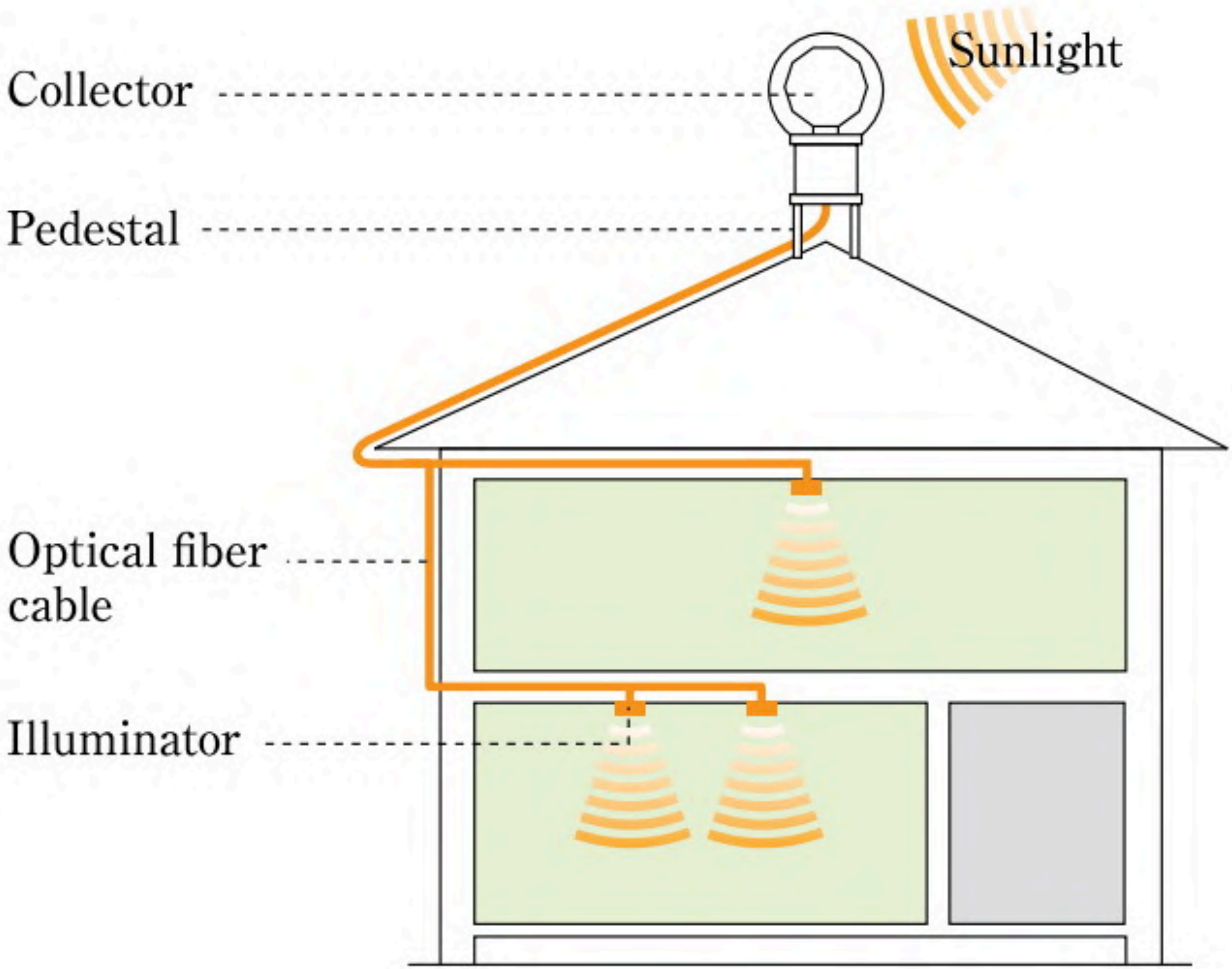
Epidemiology: Nationally, between 2006-2010, approximately 20% of LVAD patients acquire driveline infections. [1]

Economic Impact: The cost of index hospitalization for LVAD placement was estimated to be $119,874. However, these costs more than doubled $263,822 when patients developed sepsis, and increased even more, $869,199, when patients developed sepsis, pump-housing infections or perioperative bleeding.[2]

1. Goldstein, et al. *Continuous-flow devices and percutaneous site infections: Clinical outcomes*. 2012
2. Oz, et al. *Left ventricular assist devices as permanent heart failure therapy: the price of progress*. 2003

Stakeholder Interests

Stakeholder	Benefits	Cost	Σ
Patients	QOL, LOS, Meds, Surgery	UAEs	+
Surgeons	Decreased Reoperations, Complications, Mortalities	Retraining, UAEs	+
CHF Cardiologists	Rx/LOS, More Admissions	Retraining, UAEs	+
Care Providers	Infection Prevention, Dx,Rx	Retraining, UAEs	+
Payers	LOS Related Costs	Device Price, UAEs	+
Industry	More LVADs Sold	Production, Design	+
Hospital/ICU	LOS, Profits, Reputation	Retraining, Inventory	+

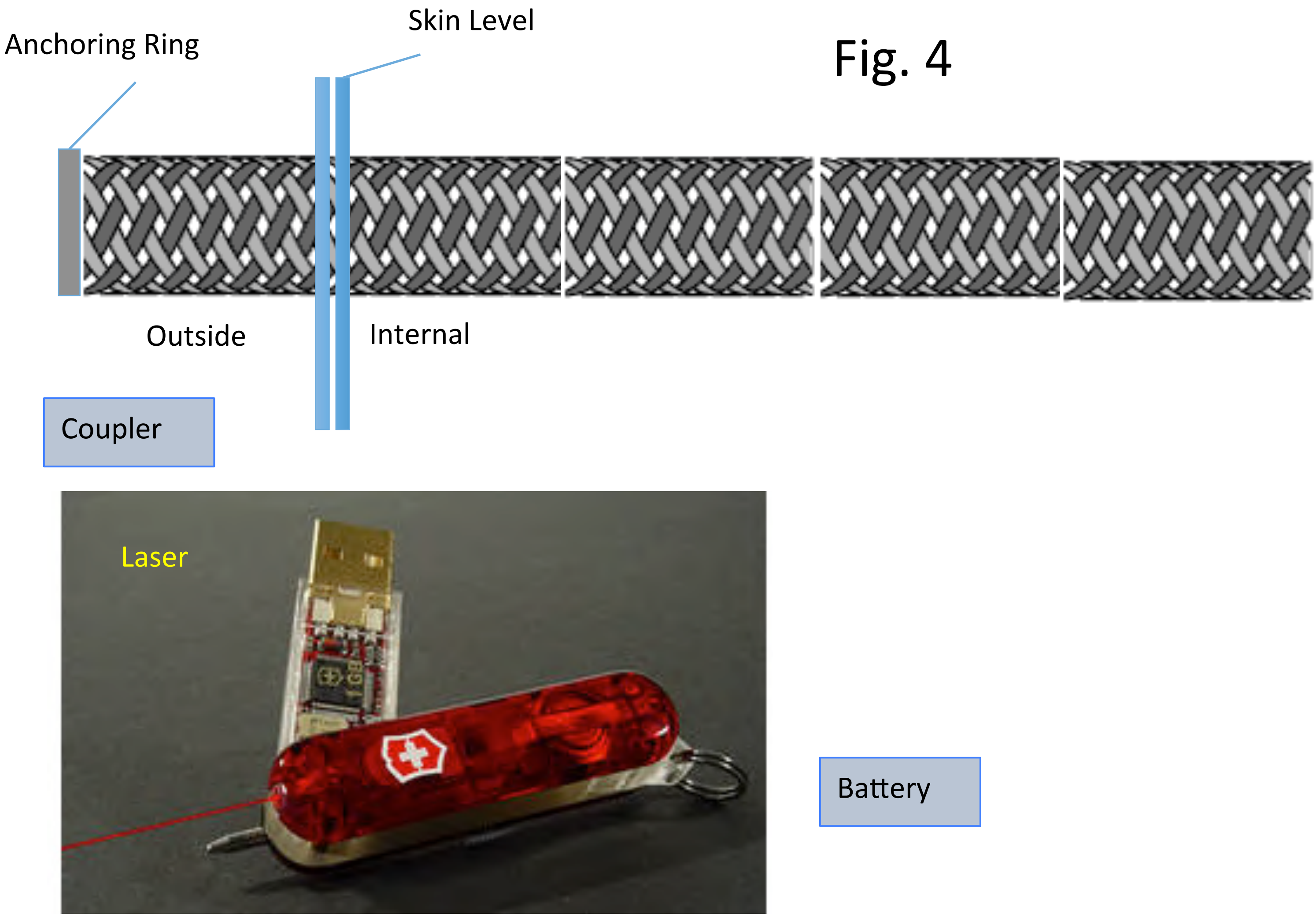

Collector
Sunlight
Pedestal
Optical fiber cable
Illuminator

Daisy Kosa S, Lok CE. The **economics** of hemodialysis **catheter**-related **infection** prophylaxis.
Semin Dial. 2013 Jul-Aug;26(4):482-93. Review.

Hong Z, **Wu** J, Tisdell C, O'Leary C, et al.
Cost-benefit analysis of preventing nosocomial **bloodstream** infections among hemodialysis patients in Canada in 2004. Value Health. 2010 Jan-Feb;13(1):42-5.

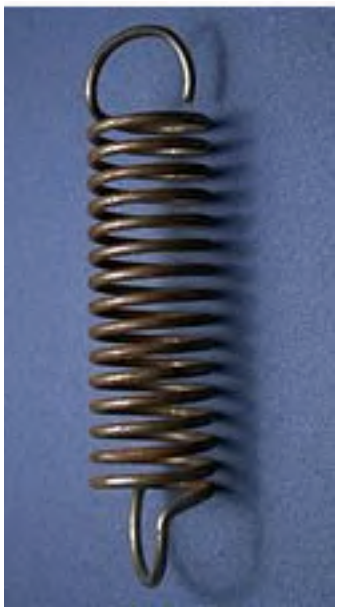
Hu KK, **Veenstra** DL, **Lipsky** BA, Saint S.
Use of maximal sterile barriers during central venous catheter insertion: clinical and economic outcomes. Clin Infect Dis. 2004 Nov 15;39(10):1441-5.

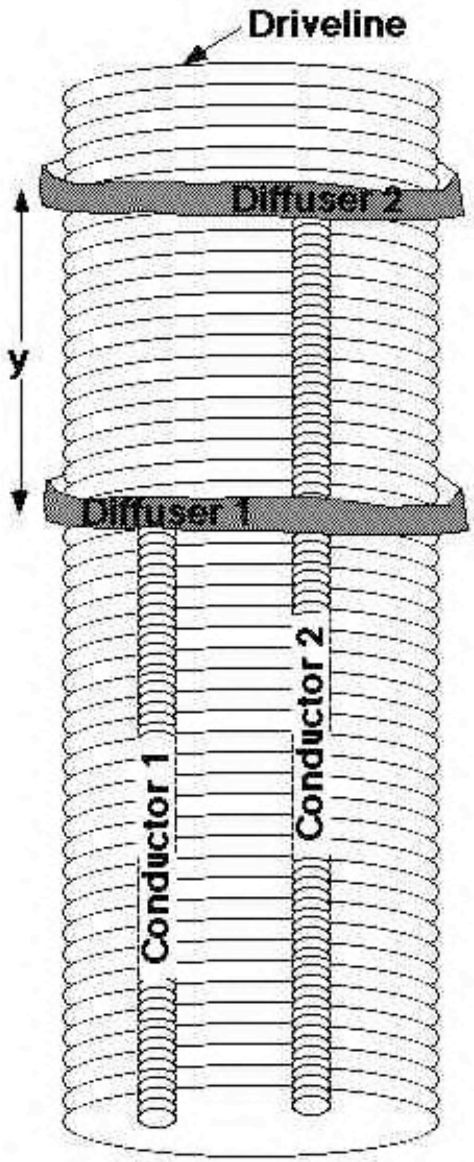
Fig. 4



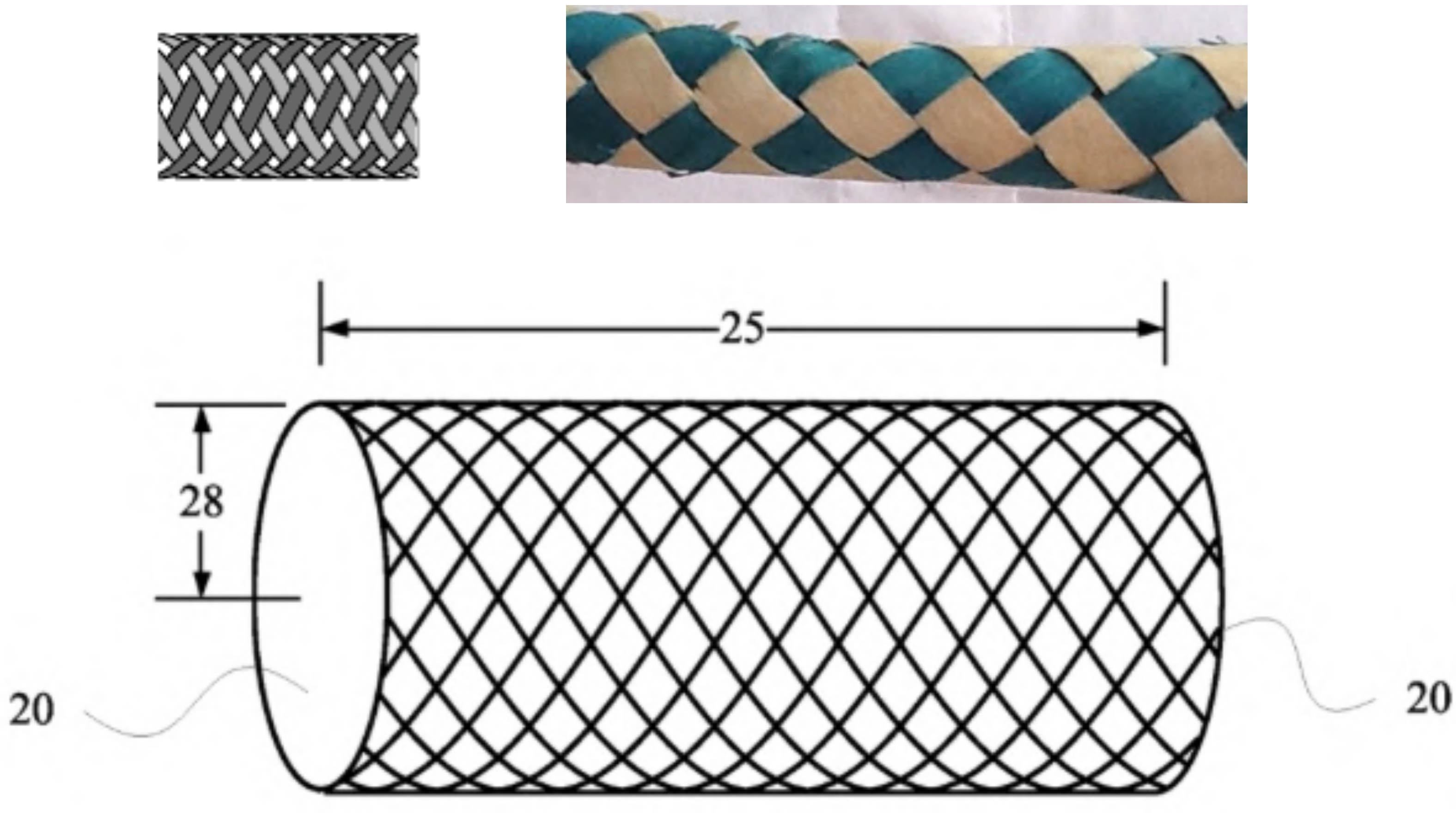
DUVS-LVAD components: Woven sleeve fits over driveline.
Anchoring ring fixes sleeve to driveline. Sleeve connects
To battery powered laser via coupler.

Fig. 5

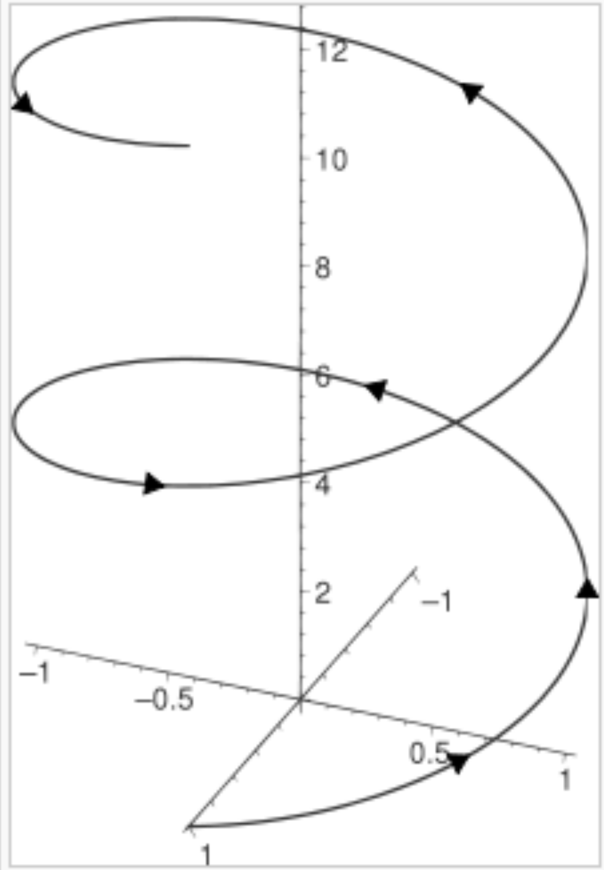




Alternate design for DUVS sleeve includes two classes of fibers for most Efficient conduction and irradiation of ultraviolet light.



Biaxial Braid (“Chinese Finger Trap”). In addition to labelled dimensions, fiber width, incident angle of helix, and Interfiber distance are critical dimensions.



The right-handed helix (cos *t*, sin *t*, *t*) from *t* = 0 to 4π with arrowheads showing direction of increasing *t*