

# THE NANOKNIFE SYSTEM HOW IT WORKS

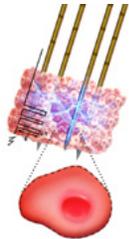


## WHAT IS IRREVERSIBLE ELECTROPORATION (IRE)?

The NanoKnife System utilizes a mechanism of action called irreversible electroporation (IRE) that selectively targets cell membranes to achieve cell death.<sup>1</sup> Here is a breakdown of how it works:

### 1 Electric Field Application

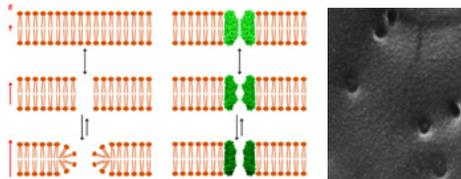
A series of short, high voltage, low energy electrical pulses are delivered between electrodes creating an electric field surrounding the target tissue.<sup>2</sup>



Electric field is generated

### 2 Membrane Permeabilization

The electric field reorganizes the lipid bilayer and permanently opens the ion channels of the cell membrane causing nanopores to form, a process known as *irreversible electroporation*.<sup>2</sup>



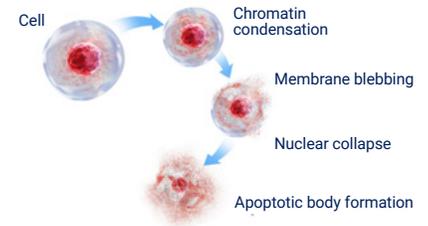
Lipid bilayer reorganization

Ion channel opening

Nanometer sized pores in cell membrane

### 3 Cell Death

Cells exposed to sufficient voltage experience unregulated fluid and ionic shifts leading to an apoptotic-like cellular death.<sup>1</sup>

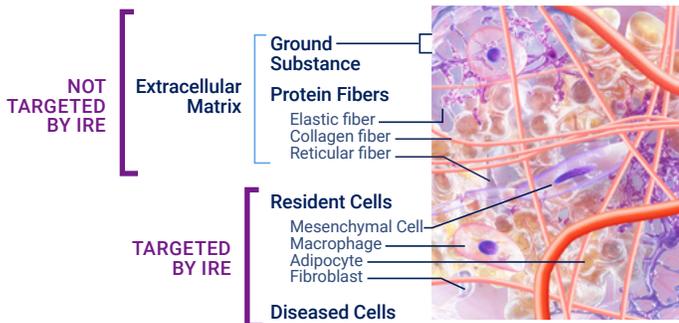


Process of cell death through apoptosis.<sup>13</sup>

Irreversible electroporation (IRE) selectively targets cell membranes. The targeted cells are destroyed while the extracellular matrix (ECM) is preserved.

## WHAT IS THE ECM?

The extracellular matrix (ECM) fills the space between cells and binds cells and tissues together.<sup>4</sup> Because the ECM does not contain a lipid bilayer it remains intact following IRE.



The ECM is crucial for several reasons:

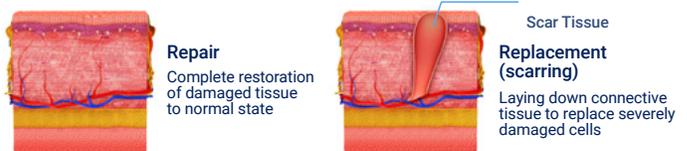
- Structure:** it provides a template that guides the formation of tissues and organs acting as scaffold for cells and maintains the structural integrity of the tissue.<sup>7,8</sup>
- Signaling:** it regulates cellular function such as growth, proliferation and gene expression.<sup>6,8</sup>
- Tissue Regeneration:** it provides a pro-regenerative microenvironment for tissue repair, acting as both a dynamic scaffold to protect and support healing wounds.<sup>9</sup>

### TYPICAL COMPONENTS OF TISSUE.<sup>5</sup>

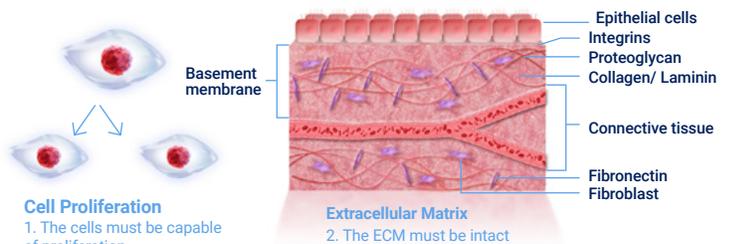


## THE BIOLOGICAL RESPONSE TO IRE

In response to IRE, the body begins the healing process. Across the healing spectrum there are two distinct types of regeneration:<sup>9</sup>



Full recovery to the original state can only occur if both the following conditions are fulfilled:<sup>10</sup>



IRE allows for the existence of both conditions which facilitates post ablation histological and functional tissue regeneration.<sup>12,13</sup> The recovery of function follows the healing cascade:<sup>11</sup>



The ability to heal is patient-specific and individuals may not see consistent results. However, soft tissue ablation with the NanoKnife system preserves structures so that function may be recovered when cells repopulate within the ablated area.

## REFERENCES:

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9. Keane, T. Scarring vs. Functional Repair: Matrix-based strategies to regulate tissue healing *Adv Drug Deliv Rev*. 2018 April: 407-419
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12. Rubinsky B, Onik G, Mikus P. Irreversible electroporation: a new ablation modality—clinical implications. *Technol Cancer Res Treat*. 2007 Feb;6(1):37-48. doi: 10.1177/153303460700600106
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## INDICATIONS FOR USE:

**US:** The NanoKnife System with six outputs is indicated for surgical ablation of soft tissue, including prostate tissue.

**CANADA:** The NanoKnife System is a medical device for cell membrane electroporation. Electroporation is a phenomenon that occurs in cell membranes as cells are exposed to an electrical field of sufficiently high intensity. The electric field acts as a physical stimulus, bringing about alterations in cell membranes that result in increased permeability.

**EU:** The NanoKnife System is indicated for the ablation of prostate tissue in patients with intermediate risk prostate cancer.

## Contraindications:

- Ablation procedures using the NanoKnife System are contraindicated in the following cases:
- Ablation of lesions in the thoracic area in the presence of implanted cardiac pacemakers or defibrillators
- Ablation of lesions in the vicinity of implanted electronic devices or implanted devices with metal parts.
- Ablation of lesions of the eyes, including the eyelids.
- Patient history of Epilepsy or Cardiac Arrhythmia
- Recent history of Myocardial Infarction.

## Warnings:

- **EU Only:** The NanoKnife device has been evaluated for the ablation of prostate tissue in patients with intermediate risk prostate cancer. The use of this device in other organs for other disease states has not been fully evaluated.
- Clinical Issues (including Arrhythmia, Hypertension, and Thrombus Risks)
- Patients with Q-T intervals greater than 500 ms (milliseconds) are at an increased risk for inappropriate energy delivery and arrhythmia. Verification of proper function of a synchronization device before initiating energy delivery is essential in these patients.
- Asynchronous energy delivery (90 PPM (Pulses Per Minute)) might trigger atrial or ventricular fibrillation, especially in patients with structural heart disease. Ensure that proper interventions (e.g. defibrillator) and appropriately trained personnel are readily available for dealing with potential cardiac arrhythmias.
- Using QRS synchronization devices whose output is not compatible with the specifications listed in this manual may result in arrhythmias including ventricular fibrillation.
- Adequate precautions should be taken for patients with implantable electrical devices. Note the contraindication in certain patients.
- There are potential risks associated with the location of the ablation: near the pericardium (tachycardia), or near the vagus nerve (bradycardia).
- Additional patients may be at risk with insufficient muscle blockade or anesthetic analgesia (reflex tachycardia and reflex hypertension); patients with abnormal sinus rhythm prior to an ablation (arrhythmia); patients with a history of hypertension (hypertension); or patients with partial portal venous thrombosis, low central venous pressure (CVP), and a prothrombotic condition (venous thrombosis).

## Use of Electrodes:

- Avoid repeated vascular insult during electrode placement.
- As anticipated with a needle-related procedure, repeated vascular insult due to multiple insertions into a vessel by an electrode during electrode placement may cause thrombus.
- Ensure continuous image guidance during the needle placements. Failure to do so can lead to traumatic injury to surrounding structures.

- Care should be taken during electrode placement in areas that require tissue be separated or retracted to avoid surrounding tissue damage.
- To avoid risks of infection, always maintain the electrodes' protective packaging (cap, tubes, etc.) when the electrodes are not placed in the patient.
- Only electrode probes with intact electrical insulation must be used. Any electrodes with damaged electrical insulation must be discarded immediately and not connected to the NanoKnife Generator.
- To preserve the electrode's sterility do not remove the electrodes from the packaging until the User is ready to apply the electrode to the patient.
- Do not use the electrodes after the expiration date printed on their packaging. Observe the electrodes manufacturer's specific instructions (e.g., printed on the electrodes' packaging).
- Only use AngioDynamics Electrode Probes with the NanoKnife System Generator.
- Maintain electrical separation of the electrodes from safety ground by doing the following
- Disconnect any electrode from the Generator that is not applied to the patient.
- Avoid any clamping of the electrode's cable, unless explicitly instructed or authorized by the electrode's manufacturer.
- Do not connect any devices (e.g., measurement) to the electrodes unless they have been supplied by and specifically indicated for such a use by the manufacturer.

## Use of Generator (including Electrocutation Hazard)

- No modification of this equipment is allowed.
- To avoid risk of electric shock, this equipment must only be connected to a supply mains with protective earth.
- The Generator internally produces voltages that are dangerous and may be fatal. The Generator does not contain parts serviceable by the User, and should not be opened.
- Do not use the Generator in the presence of flammable or explosive gas mixtures.
- For electrical safety, the Generator needs grounding. Use only medical grade main power supply cords, e.g., those supplied by the manufacturer.
- Before plugging the Generator to the main, ensure that the main power cords are not damaged. Replace them if any damage is noticed – main cords cannot be repaired.
- Do not connect or disconnect the Generator from the main power cord with wet hands.
- Confirm that the main power cord will be connected to a properly grounded electrical outlet.
- Whenever necessary, replace Generator fuses only with fuses specified in this manual.
- Maintenance should be carried out only by trained personnel. The Generator must undergo periodic preventative maintenance as specified in the Maintenance and Service.
- The NanoKnife User Manual is a fundamental part of the Generator and should always accompany it. Users must refer to this manual for correct and complete information on the use of the Generator.

## Potential Adverse Effects (Rest of the world):

Adverse effects that may be associated with the use of the NanoKnife system include, but are not limited to the following: • Arrhythmia • Atrial fibrillation or flutter • Bigeminy • Bradycardia • Heart block or atrioventricular block • Paroxysmal supraventricular tachycardia • Tachycardia • Reflex tachycardia • Ventricular tachycardia • Ventricular fibrillation • Damage to critical anatomical structure (nerve, vessel, and/or duct) • Dysuria • Epididymitis • Erectile Dysfunction • Fistula formation • Haematuria • Hematoma • Hemorrhage • Hemothorax • Infection • Pneumothorax • Prostatitis • Reflex Hypertension • Unintended mechanical perforation • Urethral stricture • Urinary incontinence • Urinary retention • Urosepsis • Vagal Stimulation, asystole • Venous Thrombosis

## Potential Adverse Effects (US)

Adverse effects that may be associated with the use of the NanoKnife system include, but are not limited to the following:

- Abdominal Pain
- Arrhythmia
  - Atrial fibrillation or flutter
  - Bigeminy
  - Bradycardia
  - Heart block or atrioventricular block
  - Paroxysmal supraventricular tachycardia
    - › Reflex tachycardia
    - › Ventricular tachycardia
  - Ventricular fibrillation
- Bladder spasm
- Damage to critical anatomical structure (nerve, vessel, and/or duct)
- Fistula Formation
- Hematoma
- Hemorrhage
- Hemothorax
- Infection
- Pneumothorax
- Reflex Hypertension
- Unintended mechanical perforation
- Urinary retention
- Vagal stimulation, asystole
- Venous thrombosis

The NanoKnife System is not available in all regions. Please contact your AngioDynamics representative for availability.

The NanoKnife System must be operated by properly qualified personnel only.

Caution: Federal (USA) law restricts the use of the system by or on the order of a physician.

Refer to Directions for Use and/or User Manual provided with the product for complete Instructions, Warnings, Precautions, Possible Adverse Effects and Contraindications prior to use of the product.

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