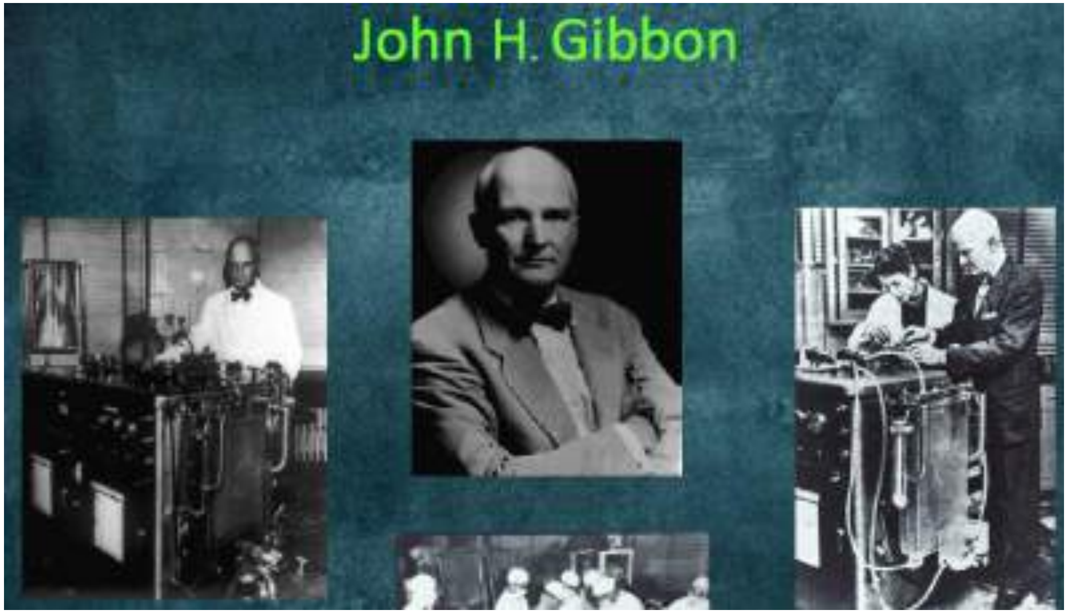
Alireza A. Ghavidel MD

Professor of Cardiovascular Surgery

NEW CARDIOPLEGIC SOLUTIONS

Esfand 1396, Feb. 2018



1954, Gibbon development the heart lung machine allowed brain ischemia but the heart become ischemic and some operations, mortality rate 65%.

In animals, potassium citrate 2.5%(77mmlo/L) in blood with good results (1950-1960).

1955, Melrose and colleagues introduced the concept of “elective reversible cardiac arrest”. Potassium citrate (77-309 mmlo/L) added to blood at 37 oC.

Potassium citrate was associated with myocardial injury, heart necrosis. As the use of potassium based Cardioplegia was abandoned for about 15 years. .

1960s, continuous coronary perfusion, with electrically induced ventricular fibrillation.

1970s, Buckberg and colleagues demonstrated that fibrillation caused sub endocardial necrosis

Shumway was protecting the heart with “profound” topical hypothermia.

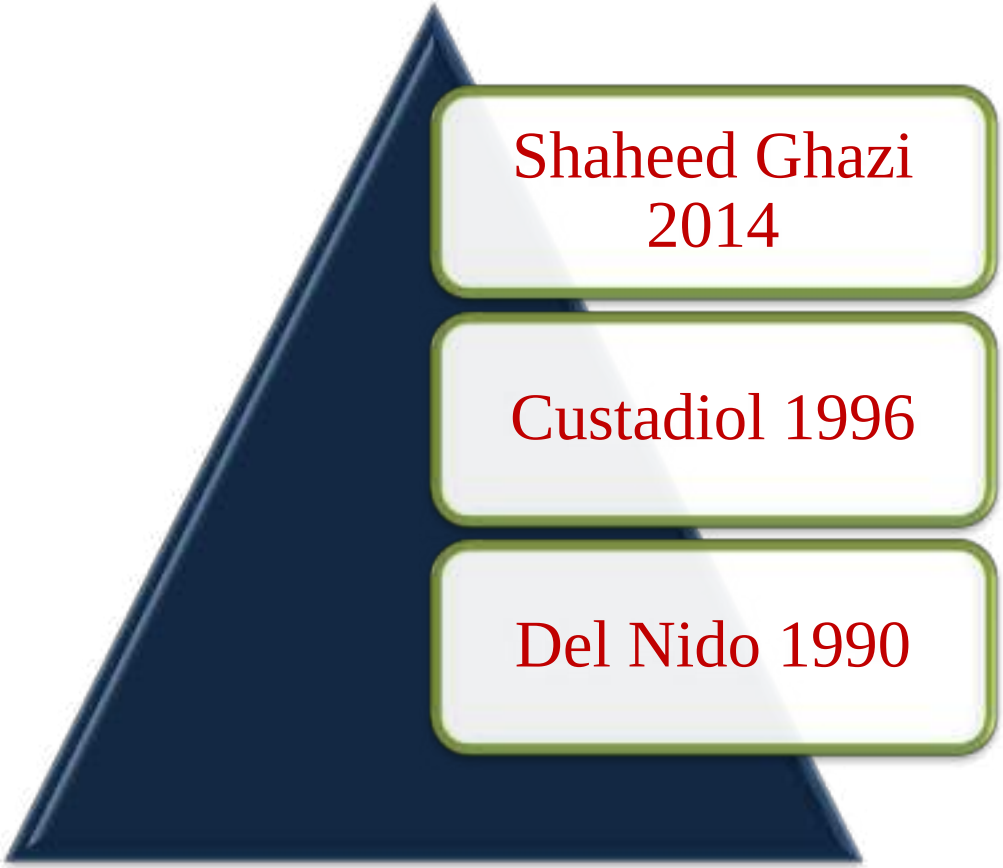
1960s, in Germany. Holscher, suggested magnesium chloride plus procaine amide of cardioprotection.

1960s, “bretschneider solution” in Gottingen, German.

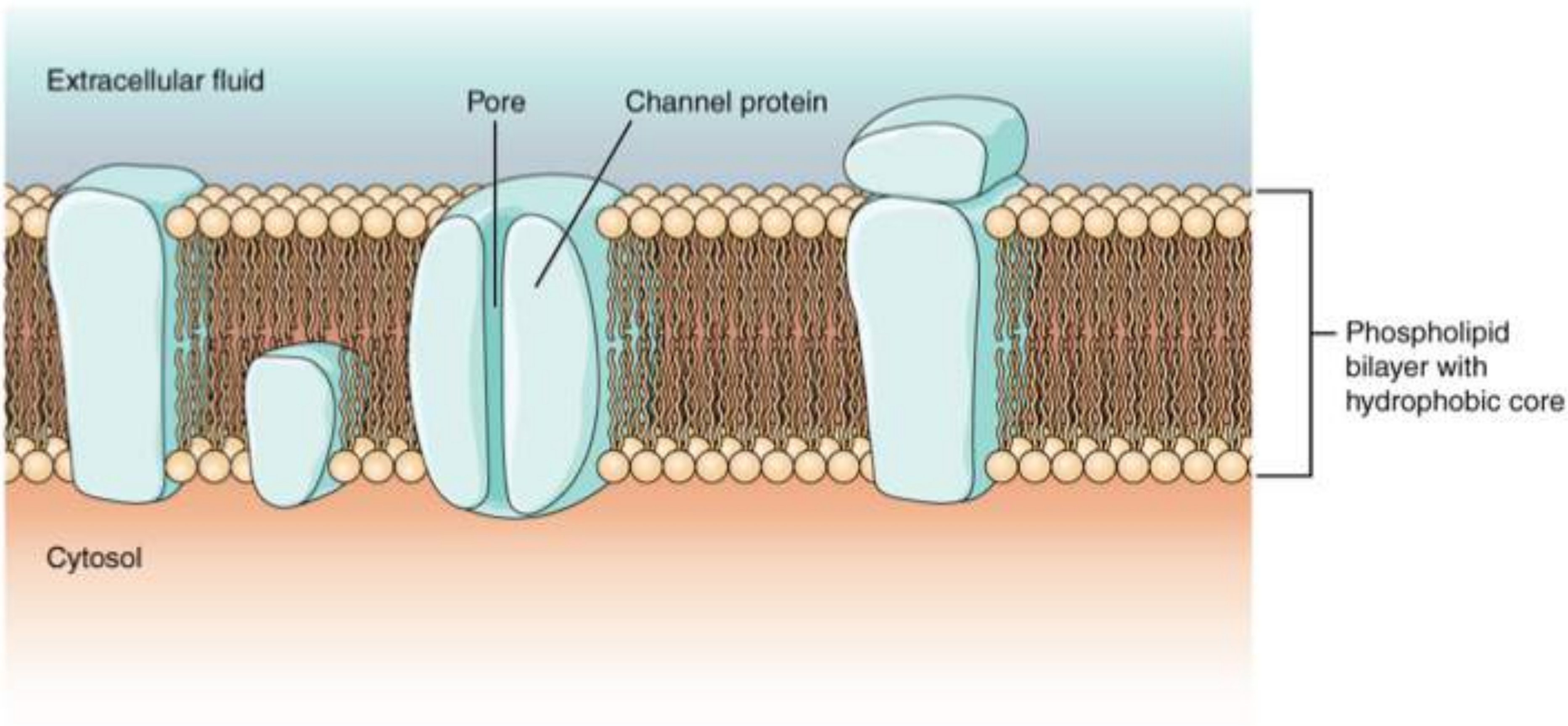
1970s Gay and Ebert, 25 mmol/L potassium chloride in dog, good protection

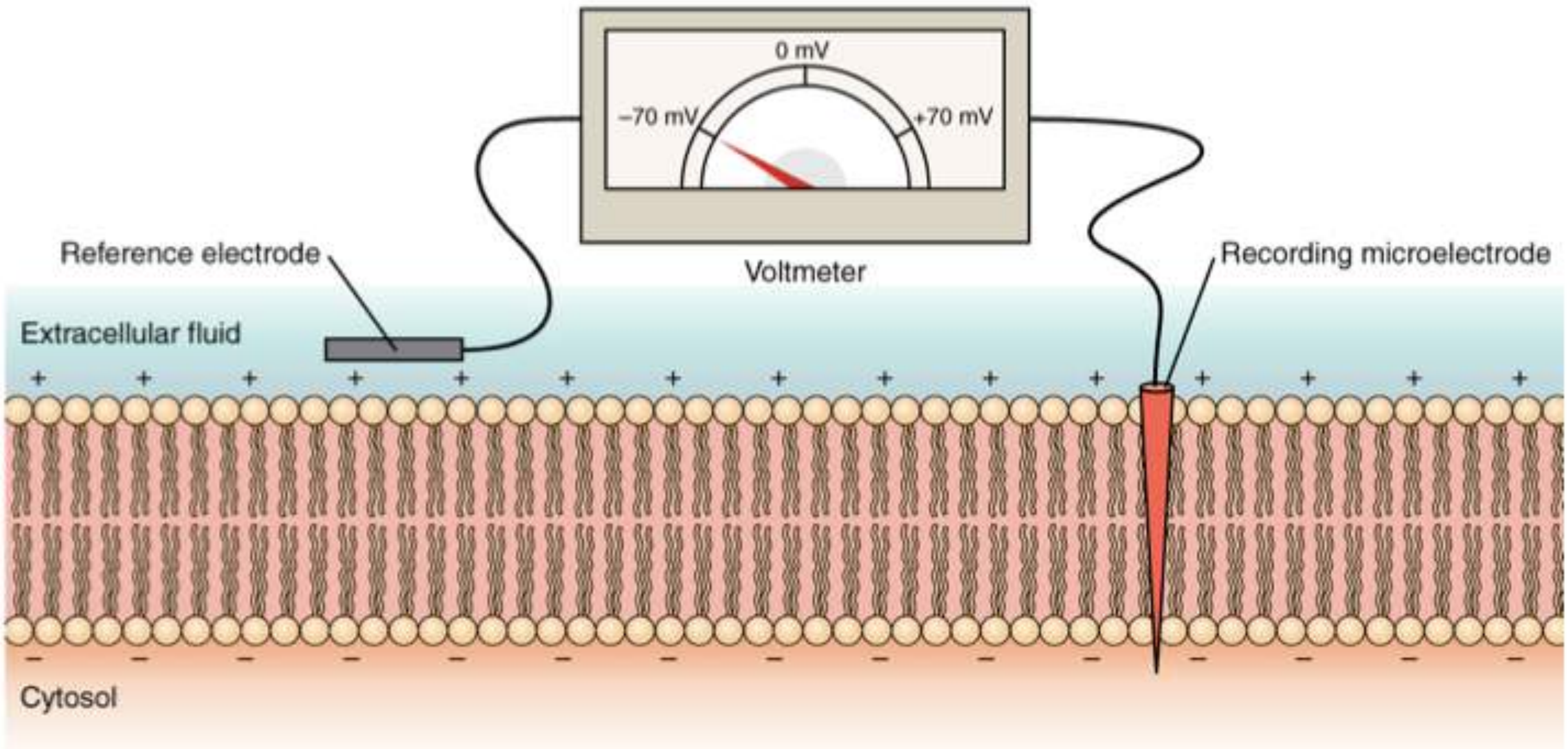
1975, Braimbrideg was first introduced St. Thomas’

Recently available cardioplegic solution in IRAN



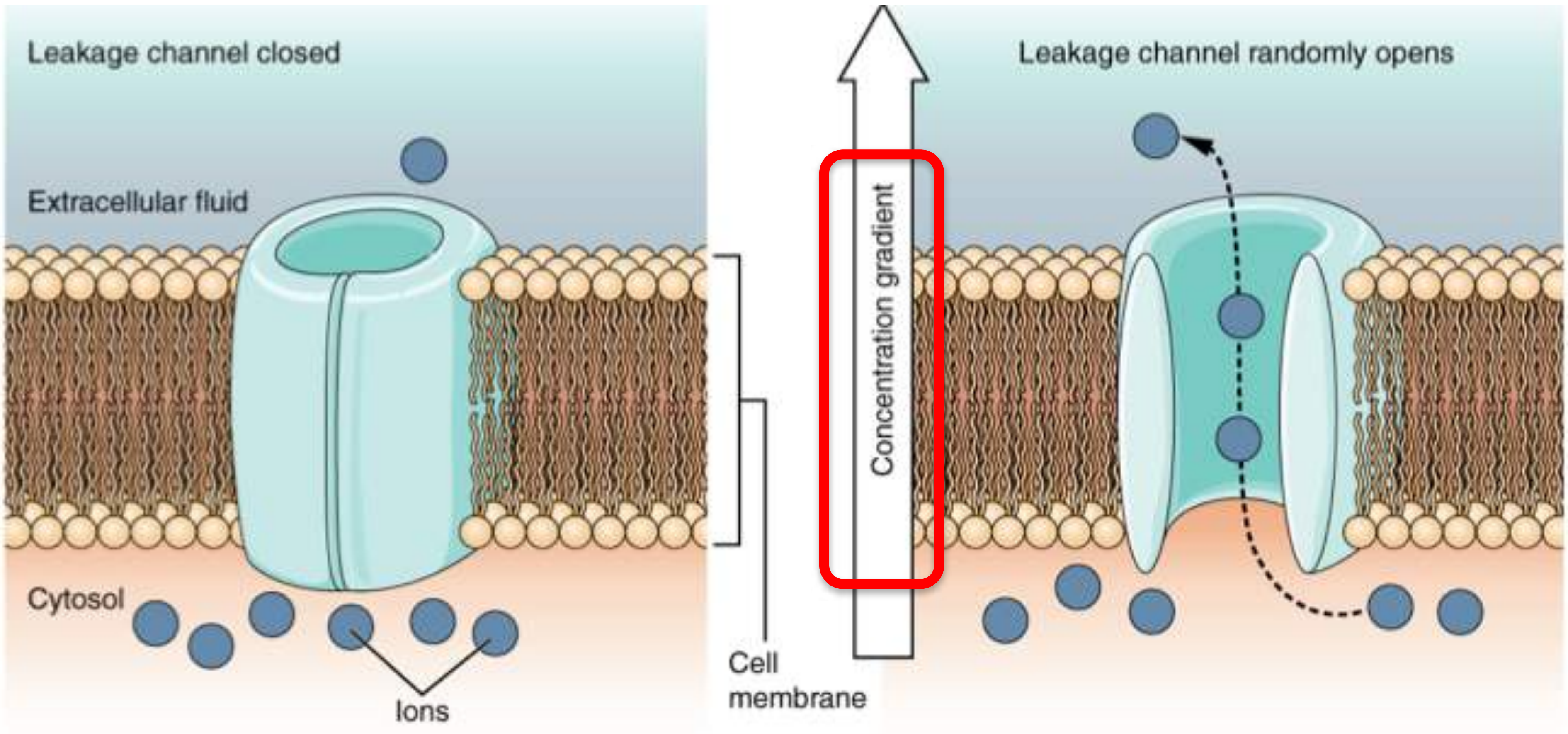
Cell Membrane Physiology



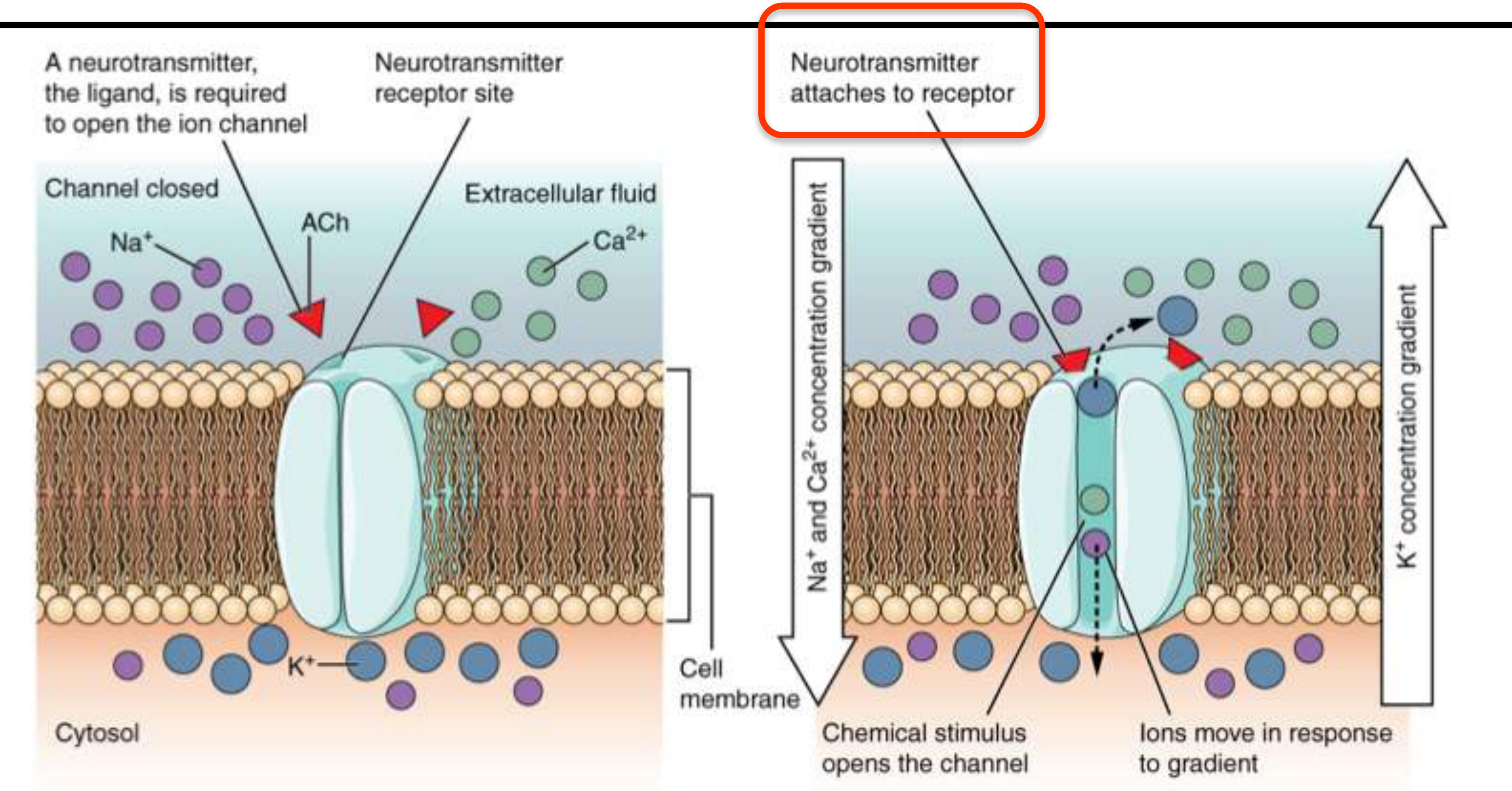


0 mV
−70 mV
+70 mV
Voltmeter
Reference electrode
Recording microelectrode
Extracellular fluid
Cytosol

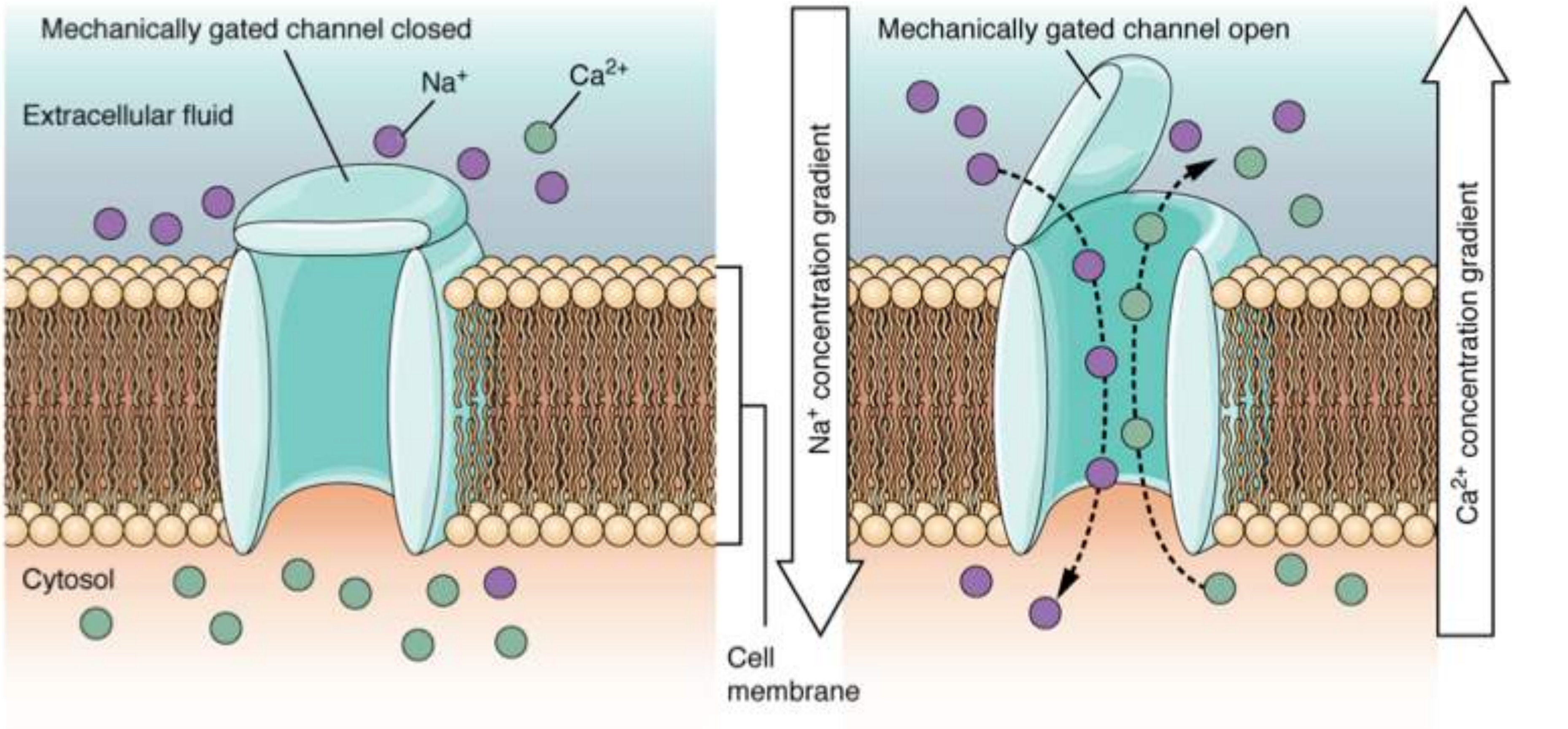
Leakage channel



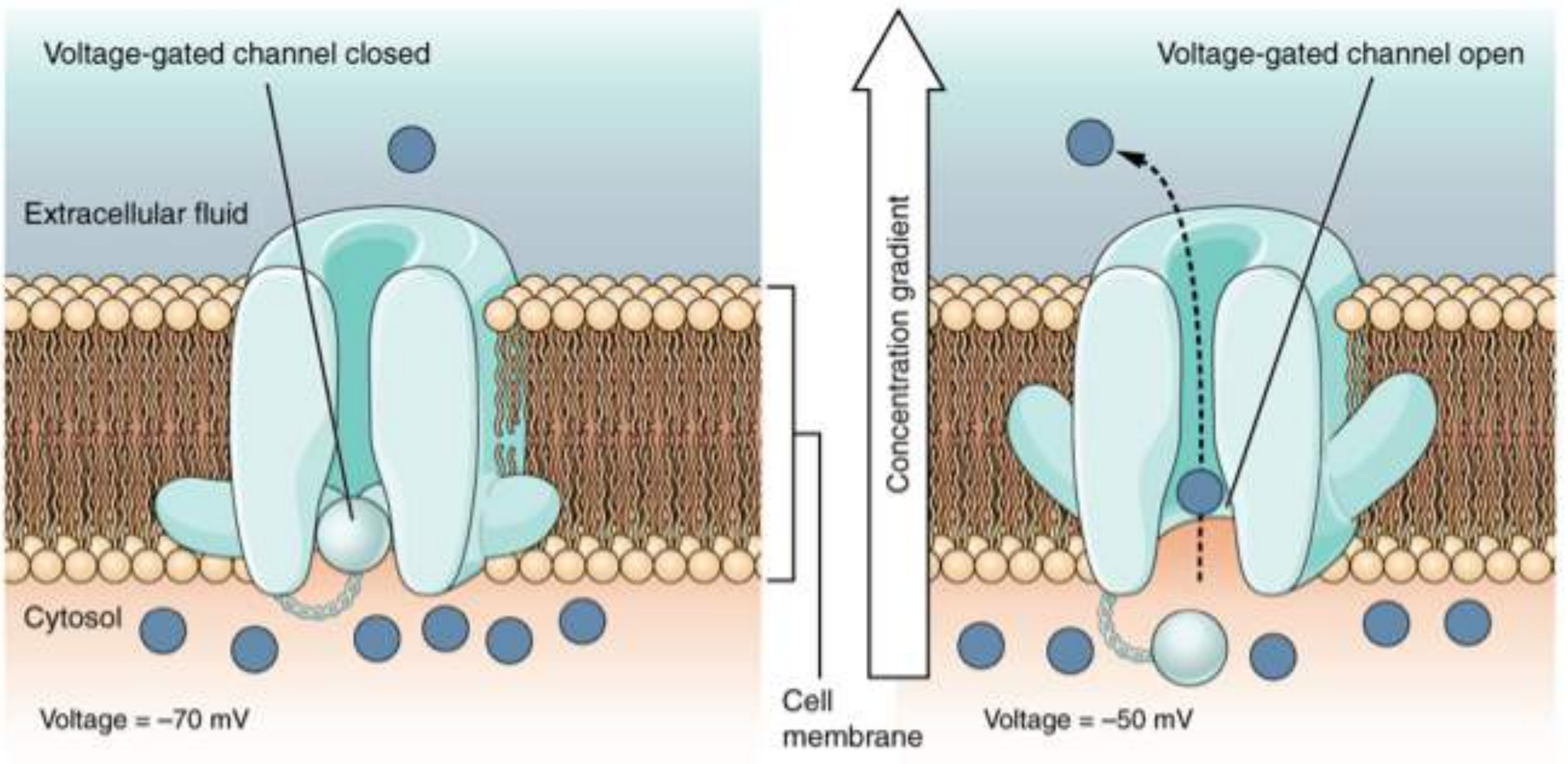
Ligand-Gated channels

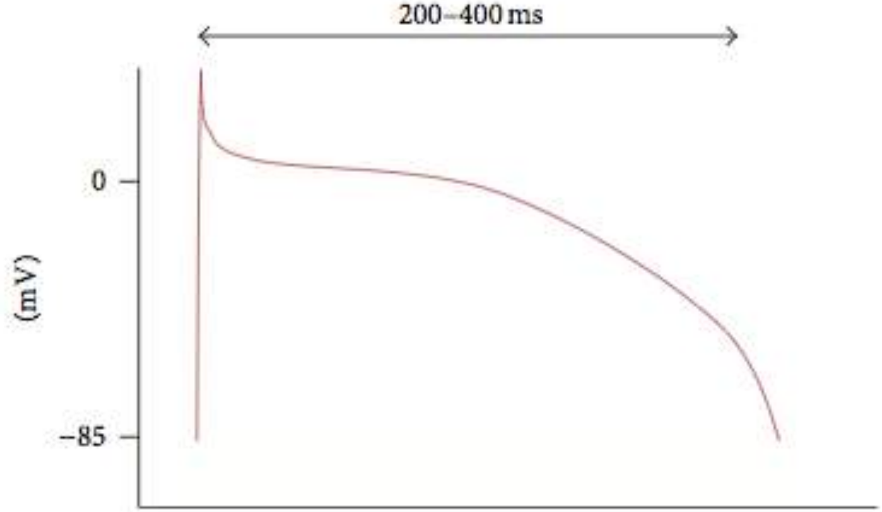


Mechanically Gated Chanel Somatosensation



Voltage-gated channel





(a)

Nernst equation (equilibrium potential)

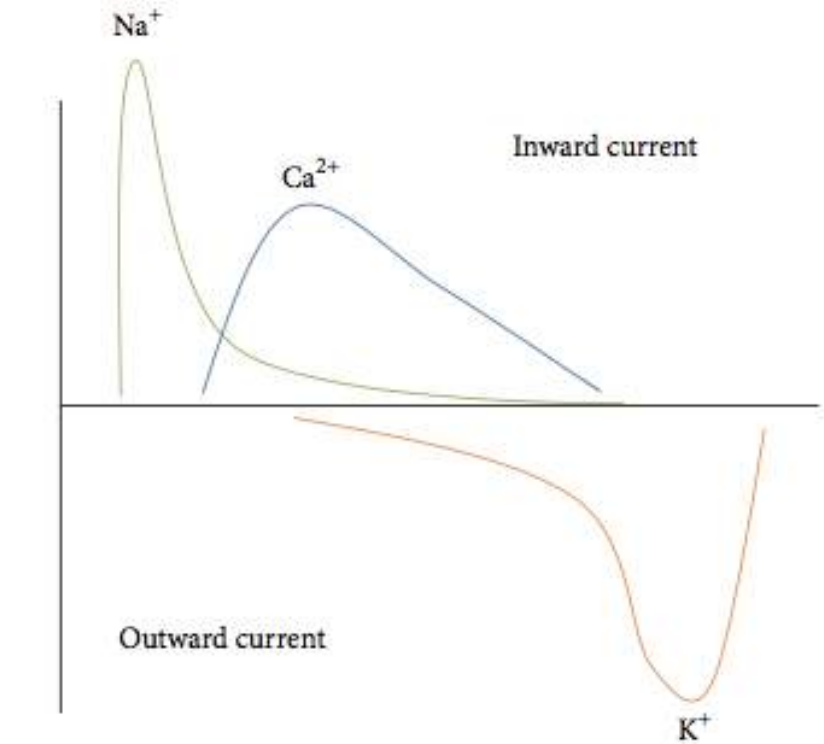
$$E_X = -61 * 1/Z_X * \log[X]_I/[X]_E$$

E_X ... equilibrium potential for ion X

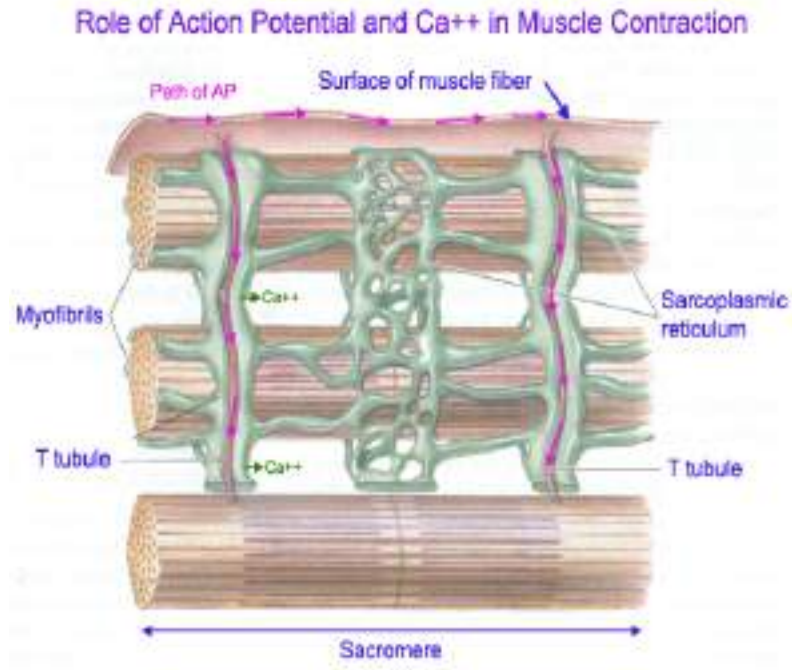
Z_X ... valency for ion X

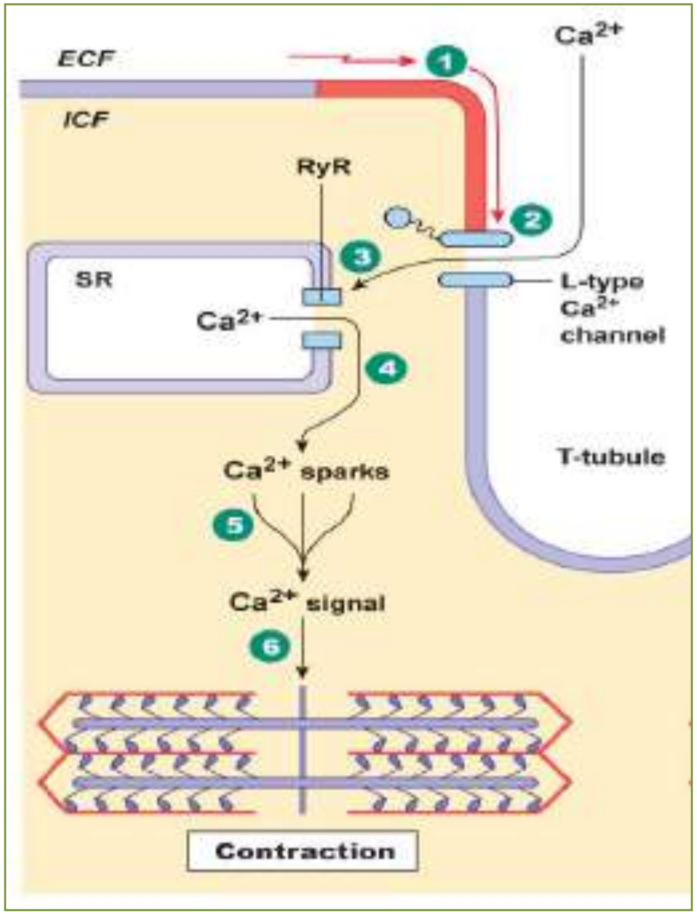
X_I ... intracellular concentration

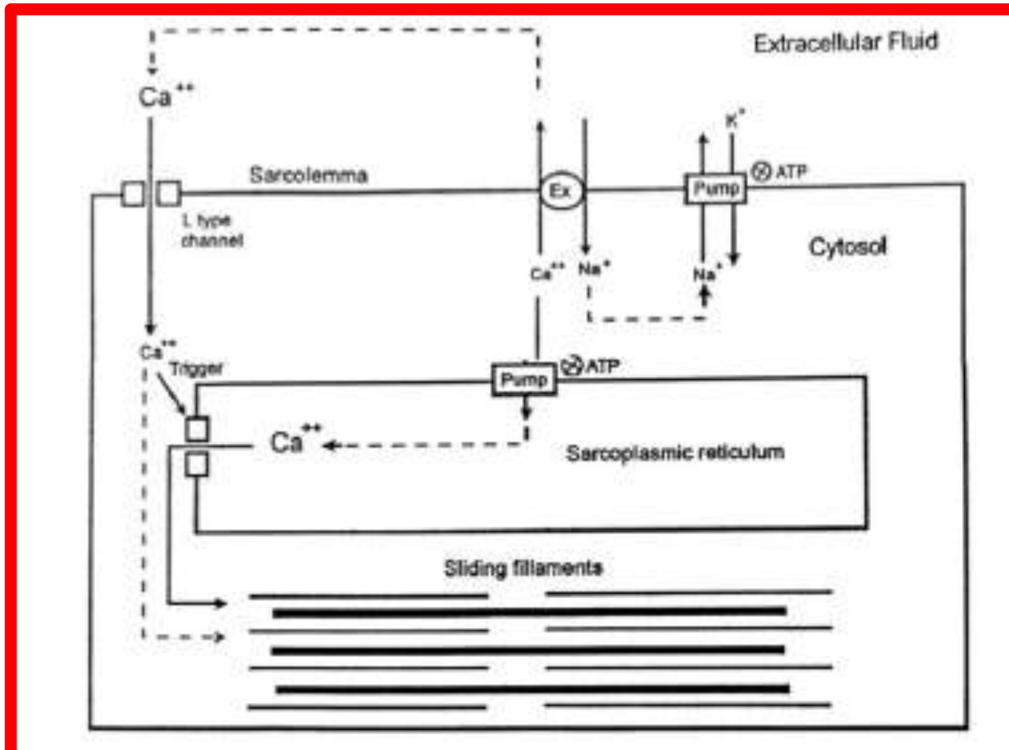
X_E ... extracellular concentration



(b)




ECF
ICF
Ca2+
RyR
SR
Ca2+
L-type
Ca2+
channel
T-tubule
Ca2+ sparks
Ca2+ signal
Contraction
1
2
3
4
5
6


Extracellular Fluid
Ca++
Sarcolemma
L type
channel
Ex
Pump
ATP
K+
Cytosol
Ca++
Na+
Na+
Ca++
Trigger
Pump
ATP
Ca++
Sarcoplasmic reticulum
Sliding fillaments

Summary on How Cardioplegia will be performed

1. Increase of extracellular myocardial K^+-concentration (e.g. St.Thomas, EC, UW, Celsior®)

2. Increase of extracellular myocardial concentration of ionised Mg^{2+}(e.g. Cardioplegin®, St.T.)

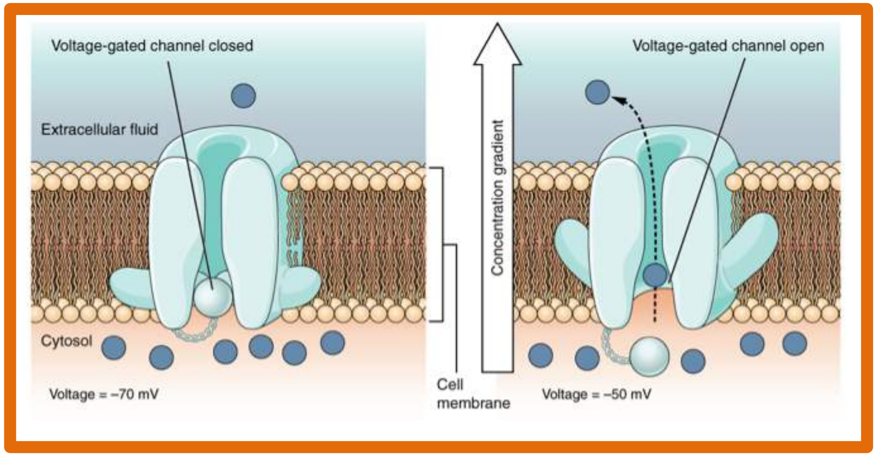
3. Simultaneous reduction of extracellular myocardial concentration of Na^+ and ionised Ca^{2+} (CUSTODIOL®)

Hyperkalemia changes the cellular resting membrane potential (E_m) of cardiac myocytes towards a less negative value (i.e., closer to zero).

The resting membrane potential is largely maintained via an adenosine triphosphate (ATP) driven primary active 3Na+/2K+ exchange pump creating bot chemical and electric gradients across the cellular membrane and via a passive K+ outward flux

. As the cardiac myocyte membrane is most permeable to K+ ions but relatively impermeable to other ions, *Em* potential is close to the K+ equilibrium potential of −91 mV (Nernst equation,) and approaches −85 mV (Goldman-Hodgkin-Katz voltage equation).

Two type of Cardioplegic solutions

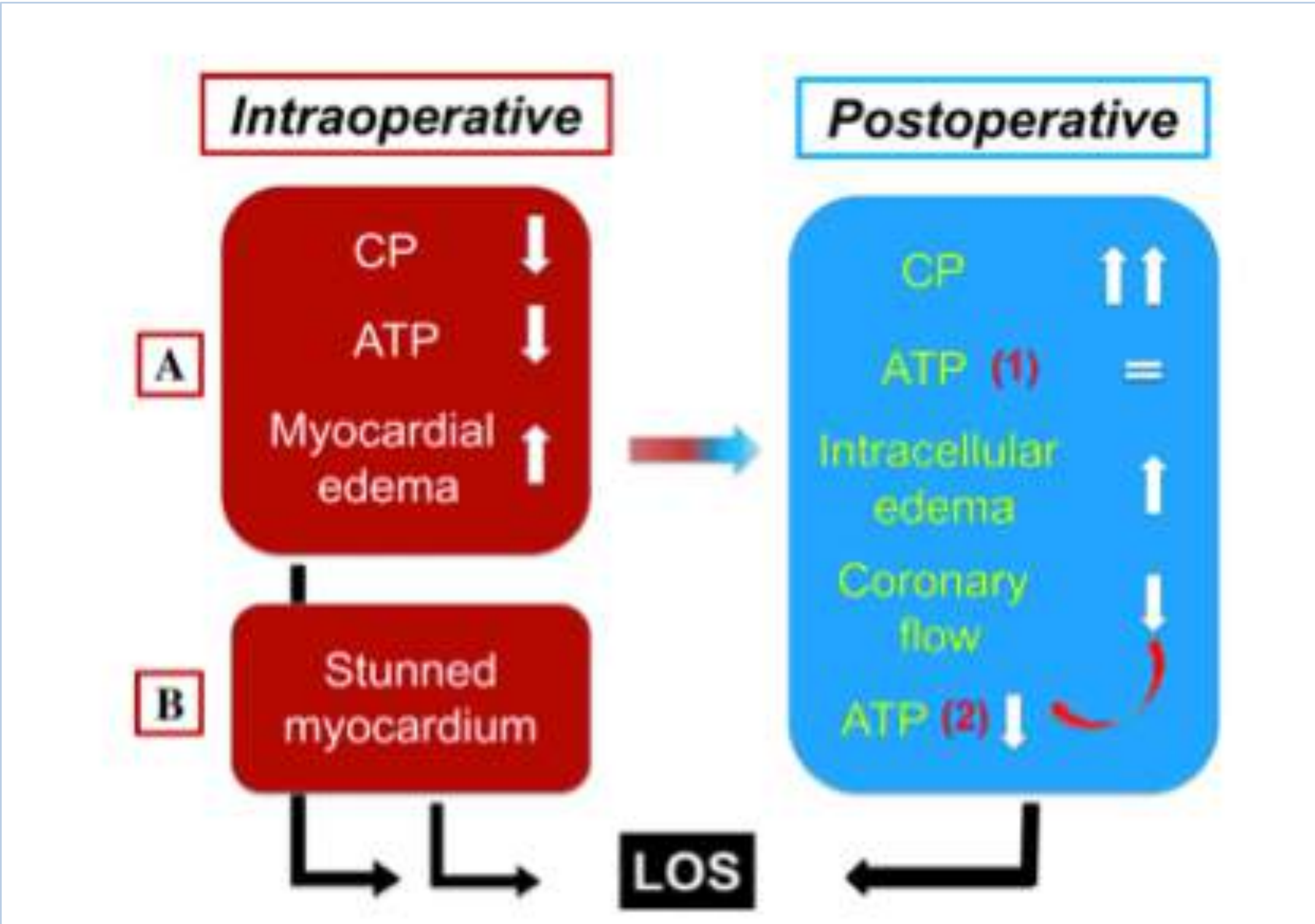


Intracellular

Custadiol, Bretschnedr

Extracellular

St. Thomas, Bukberg


Intraoperative
Postoperative
A
CP
ATP
Myocardial edema
B
Stunned myocardium
CP
ATP (1) =
Intracellular edema
Coronary flow
ATP (2)
LOS

Stunning

- Partially Reversible
- May be accompanied by endothelial dysfunction (NO) causing reduced coronary blood flow
- Result of ischemia-reperfusion insult
- Mediated by increased intracellular Ca accumulation
- Recovery in Hs,Wks

Hibernation

- Partially Reversible
- Related to poor myocardial blood flow
- Chronic
- Recovery Wks,Mo

Necrosis

- Irreversible
- Hyper contracture - “contracture band necrosis”, “stone heart”
- Osmotic/ionic dysregulation, membrane injury
- Cell swelling&disruption
- Lysis

Custadiol

H. J. Bretschneider (1922-1993)

Original manuscript

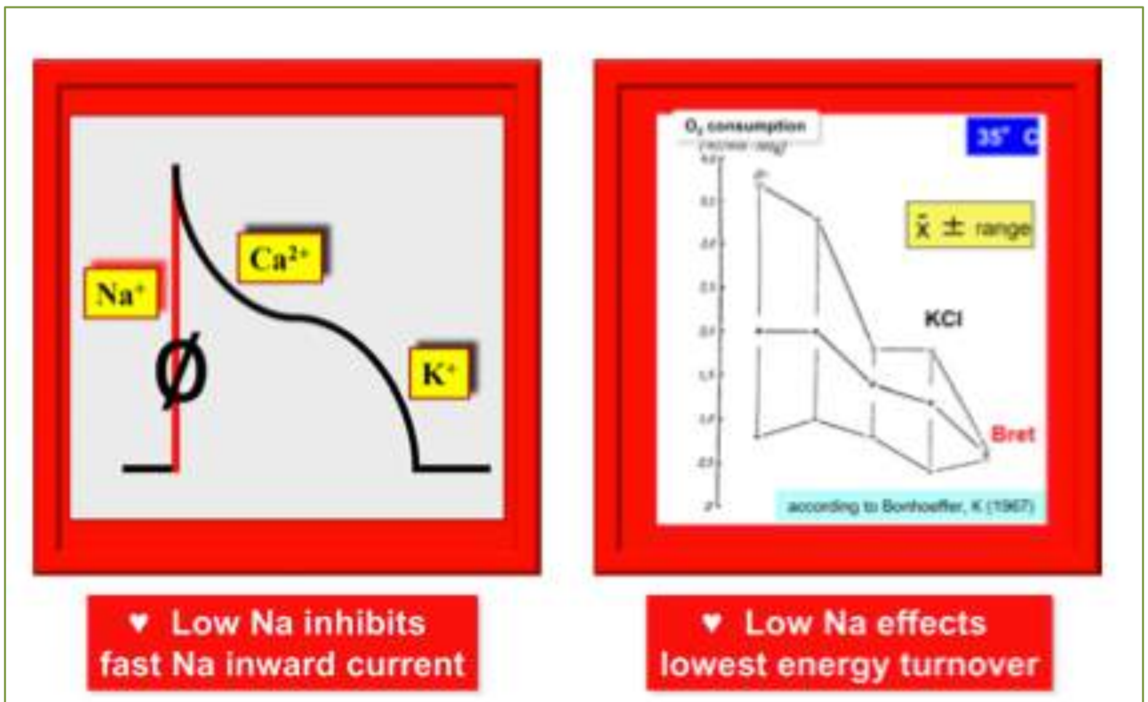
Component (mM)	BR no 3	BR-HTK	STH-1	STH-2
NaCl	12	18	144	120
$NaHCO_3$				10
KCL	10	10	20	16
$MgCl_2$	2	4	16	16
$CaCl_2$		0.02	2.2	1.2
Procaine–HCl	7.4		1	
Mannitol	239	33		
Histidine		180		
Histidine–HCl		18		
Tryptophan		2		
α-ketoglutarate		1		
pH	5.5–7.0	7.1 (25°C)	5.5–7.0	7.8
Osmolality (mOsm/Kg H_2O)	290 (320)	280 (302)	300–320	285–300

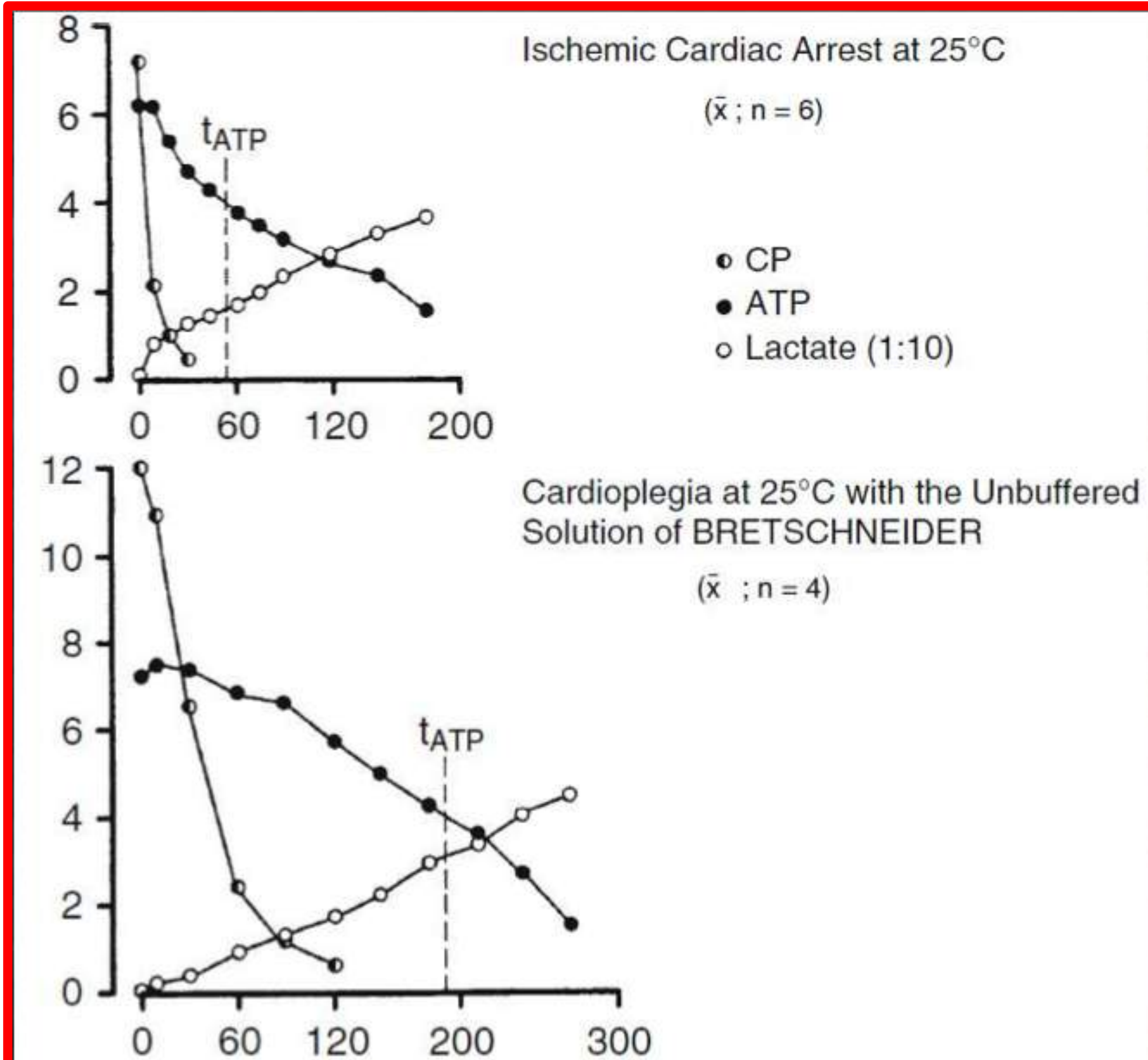
The mode of action with CUSTODIOL®

1. Low viscosity
2. Low Na^{+}-concentration (15 mmol/l)
3. Low K^{+}-concentration (10 mmol/l)
4. Intracellular Ca^{2+} -concentration (15µmol/l)
5. High buffer capacity (198 mmol/l HISTIDINE).

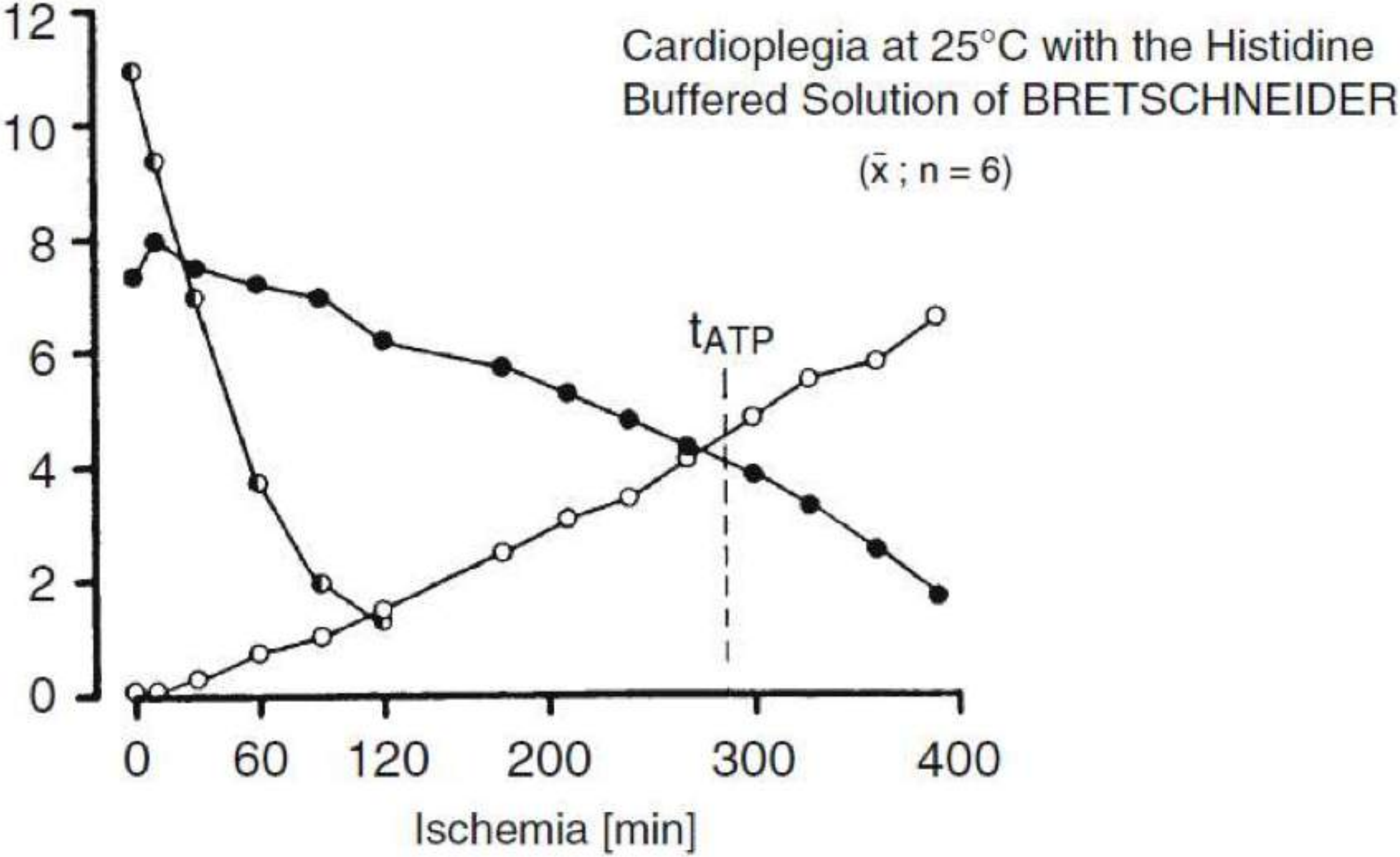
If you significantly reduce sodium, the fast inward current is inhibited and the heart is arrested.

To conclude, low-sodium effects low est energy turnover.





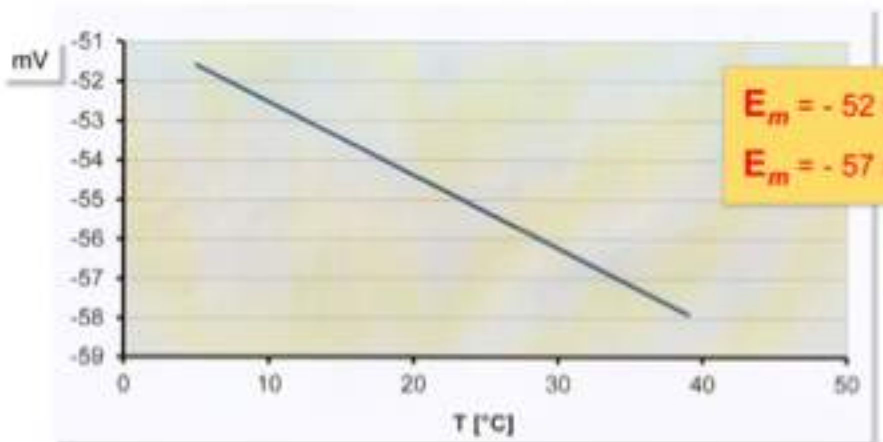
Ischemic Cardiac Arrest at 25°C
($\bar{x}$; n = 6)
t_{ATP}
CP
ATP
Lactate (1:10)
8
6
4
2
0
0
60
120
200
Cardioplegia at 25°C with the Unbuffered Solution of BRETSCHNEIDER
($\bar{x}$; n = 4)
t_{ATP}
12
10
8
6
4
2
0
0
60
120
200
300


Cardioplegia at 25°C with the Histidine
Buffered Solution of BRETSCHNEIDER
(x̄ ; n = 6)
tATP
12
10
8
6
4
2
0
0
60
120
200
300
400
Ischemia [min]

Custodiol Cardioplegia: A Single-Dose Hyperpolarizing Solution

Claus J. Preusse, MD, PhD

Department Cardiac Surgery, University Bonn, Germany



E_m = - 52 mV (8° C)

E_m = - 57 mV (35° C)

$$[Na_i]^2 : [Na_e]^2 = Ca_i^{2+} : Ca_e^{2+}$$

⬇

$$Ca_e^{2+} : [Na_e]^2 = 1.5 \text{ mM} : [150 \text{ mM}]^2 = 0.66 \times 10^{-4}$$

⬇

150 mM ➡ 15 mM (1/10)

⬇

$$Ca_e^{2+} : [Na_e]^2 = x : [15 \text{ mM}]^2 = 0.66 \times 10^{-4}$$

$$x = 0.015$$

♥ If Na_e is reduced to 1/10, Ca_e^{2+} must be reduced to 1/100 even water acts as a buffer. Imagine you have 10,000 L of water, pure water, and you add one drop of an acid inside, the pH remains constant. But, if you have only 1 mL of water and put the same drop of acid inside, the pH will immediately change. That means buffer concentration plays a role. Therefore, if people have used only 10 mMol/L bicarbonate, e.g., in St. Thomas' solution, it is almost nothing

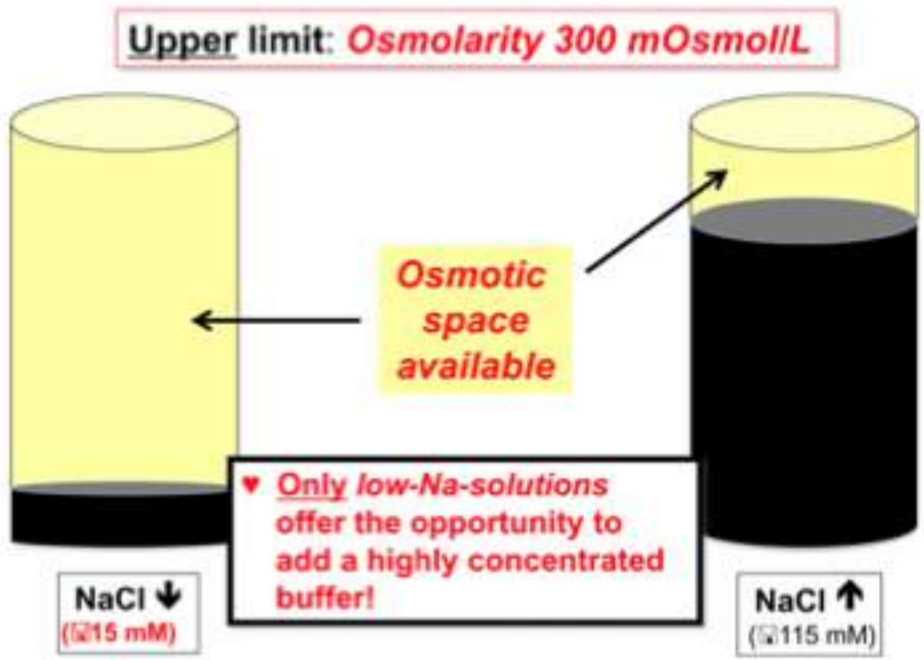


Figure 4. Significance of high or low Na concentrations on the osmotic for effective buffering.

HTK Solution*

Sodium	➡	15	mM
Calcium	➡	0.02	mM
Potassium	➡	10	mM
Magnesium	➡	4	mM
Histidine/histidine-hcl	➡	180/18	mM
Tryptophan	➡	2	mM
α-Ketoglutarate	➡	1	mM
Mannitol	➡	30	mM

Besides the buffer effect, histidine acts as free radical scavenger, so that the solution has two scavengers: the first one is histidine and the second one is mannitol. Therefore, using this solution, there's no danger for an

Electrolytes in Cardioplegic Solutions

		Na+	K+	Mg++	Ca++	
St.Thomas		117	16	16		
Marschall		80	80	35		
Cardioplegin®				120		
BCP		120	18			
Viaspan®		30	125	5	1,5	
Euro Colins		10	115			
Celsior®		100	15	13	0,25	
Custodiol®		15	10	4	0,015	

Recommended ischemic time with CUSTODIOL®

1. Open heart surgery: up to 3 hours
2. In-situ operations in kidney and liver: up to 4 hours
   (e.g. resection of tumor, aneurysm etc.).
3. Heart Transplantation: 6 hours
4. Kidney Transplantation: 20 hours
5. Liver Transplantation: 15 hours

- Costodiol prolongs ischemia tolerance in organs requiring protection mainly by two mechanisms of action

- The electrolyte composition of Custodiol prevent the trigger of

HTK seems to preserve not only the myocardium but also the coronary artery endothelium.

  - Buffer histidine retards the fall in PH during organ ischemia
  - Ketoglutarat is a substrate for aerobic energy production
  - Tryptophan has been claimed to have a membrane protective action
  - Mannitol is considered to prevent the emergence of cell edema

Dosage and Administration

- Perfusion time : about 6-8 minutes
- Perfusion Technique:
  - Hydrostatic perfusion
  - Perfusion pump
- The ischemia tolerance of the heart when using the HLM : 180 minutes
- The basic perfusion technique
  - Low Temperatures, and extremely low viscosity
  - Large volumes under low pressures and low temperatures necessary for perfusion

Dosage and Administration

- Temperature of solution 5-8 $^{\circ}$C
- Perfusion Volume 40-50 cc/Kg
- Perfusion Pressure (pressure in the aortic root)

Audults

- Initially 140-150 cmH2O above the level of the heart = 100-110 mmHg
- After cardiac arrest, reduce to 50-70 cmH2O = 40-50 mmHg

Infants and young children

- Initially 110-120 cmH2O above the level of the heart = 80-90 mmHg
- After cardiac arrest, reduce to 40-50 cmH2O = 30-40 mmHg

► In patients with CAD higher pressures should be maintained for long periods

Toxicological properties

Circulation volume overloading or Second dose and may by add Hemoconcentrator or diuretic drug

Disturbances of electrolyte balance hyponateremia, hypocalcemia.

Plasma levels of the amino acids tryptopan and histidine may be elevate during the first 24 hrs.
Induce acidosis during CPB time

Main Indications of CUSTADIOL

- Complex cardiac surgeries
- Minimally invasive
- Complex congenital
- Robotic Surgeries
- HOCM

Systematic Review

Custodiol for myocardial protection and preservation: a systematic review

J. James B. Edelman[1,2], Michael Seco[2], Ben Dunne[3], Shannon J. Matzelle[4], Michelle Murphy[4], Pragnesh Joshi[1], Tristan D. Yan[2,5], Michael K. Wilson[2,5,6], Paul G. Bannon[2,5], Michael P. Vallely[2,5,6], Jurgen Passage[1,7]

Ann Cardiothorac Surg 2013;2(6):717-728

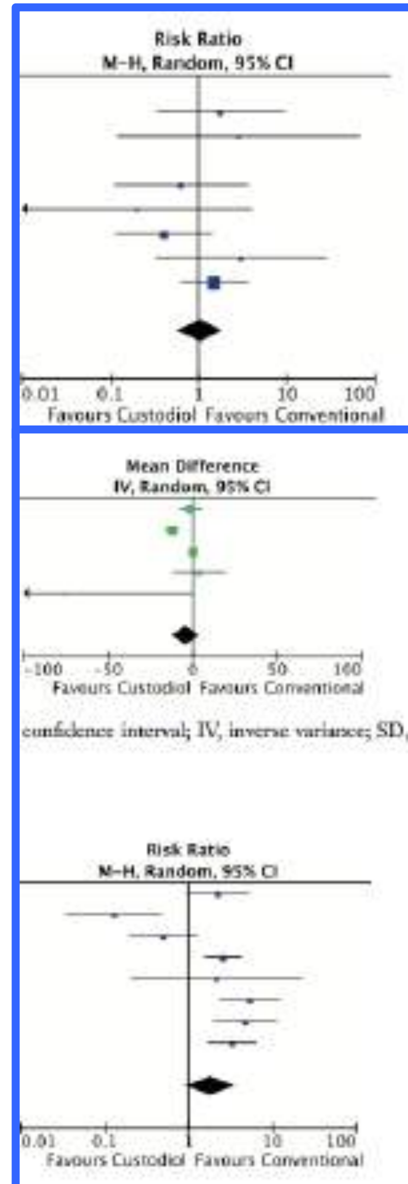
Primary end-point : 30 days Mortality

Secondary end-point: LOS Arrhythmias

The results of the available evidence suggest that Custodiol offers myocardial protection that is equivalent to that of conventional cardioplegia

A single dose cardioplegia strategy for myocardial protection has significant benefits for the performance of minimally invasive or complex cardiac surgery

There is not enough evidence to recommend the routine use of Custodiol for the performance of coronary artery bypass grafting (CABG) or other simple open cardiac surgical procedures.



Custodiol versus blood cardioplegia in complex cardiac operations: an Australian experience

Fabiano F. Viana[a,*], William Y. Shi[b], Philip A. Hayward[b], Marco E. Larobina[b], Frank Liskaser[c] and George Matalanis[b]

- January 2005 to January 2011
  - 126 (7%) utilized Custodiol and 1774 (93%) used blood cardioplegia

days.

Table 5: Early postoperative outcomes 71 propensity-matched patient pairs

Variable	Blood cardioplegia (n = 71)	Custodiol (n = 71)	McNemar's test P-value
Mortality/any morbidity	25 (35)	28 (39)	0.46

The use of Custodiol is convenient, simple and at least as safe as tepid blood cardioplegia for myocardial protection in complex cardiac operations

Available online at www.sciencedirect.com
ScienceDirect
Journal of the Egyptian Society of Cardio-Thoracic Surgery 24 (2016) 38–42
http://www.journals.elsevier.com/journal-of-the-egyptian-society-of-cardio-thoracic-surgery/
Original article

Custodiol versus blood cardioplegia in pediatric cardiac surgery, two-center study

Ebtehal A. Qulisy [a], Anas Fakiha [a], Ragab S. Debis [a], Ahmed A. Jamjoom [b], Ahmed A. Elassal [a,c], Osman O. Al-Radi [a,b,*]

Blood cardioplegia was administered in 88 (57.1%) patients, and Custodiol cardioplegia was administered in 66 (42.9%

All-cause death, LCOS, AKI and significant arrhythmia

Custodial is associated with less optimal myocardial protection andhigher adverse outcomes compared to cold blood cardioplegia in children undergoing cardiac surgery.

Veres *et al. Journal of Cardiothoracic Surgery* (2015) 10:27
DOI 10.1186/s13019-015-0226-9

JOURNAL OF CARDIOTHORACIC SURGERY

Custodiol-N, the novel cardioplegic solution reduces ischemia/reperfusion injury after cardiopulmonary bypass

Gábor Veres[1,2*], Tamás Radovits[1,2], Béla Merkely[2], Matthias Karck[1] and Gábor Szabó[1]

12 dogs underwent CPB with 60 minutes of TCA

Custodiol

Custodiol-N

(addition of L-arginin, N-α-acetyl-L-histidine and iron-chelators: deferoxamine and LK-614).

Table 1 Compounds of evaluated cardioplegic solutions

Compounds of evaluated cardioplegic solutions	Custodiol mmol/L	Custodiol-N mmol/L
Na^+	16	16
K^+	10	10
Mg	4	8
Ca^{2+}	0.015	0.020
Cl	50	30
L-histidine	198	124
N-α-acetyl-L-histidine	-	57
Tryptophan	2	2
a-ketoglutarate	1	2
Aspartate	-	5
Arginine	-	3
Alanine	-	5
Glycine	-	10
Mannitol	30	-
Sucrose	-	33
Deferoxamine	-	0.025
LK-614	-	0.0075

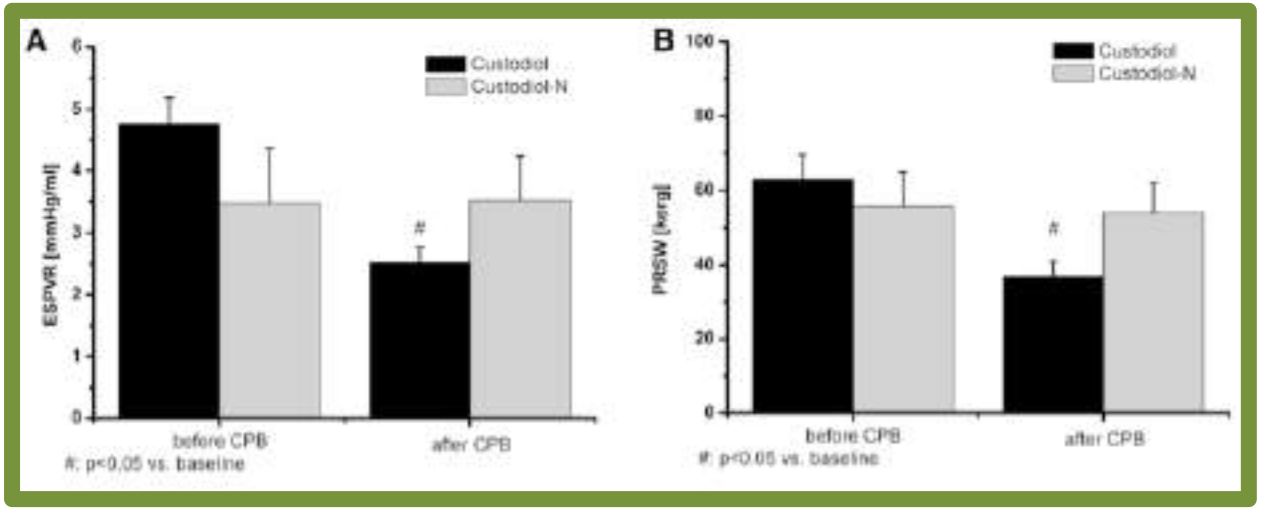
Study method

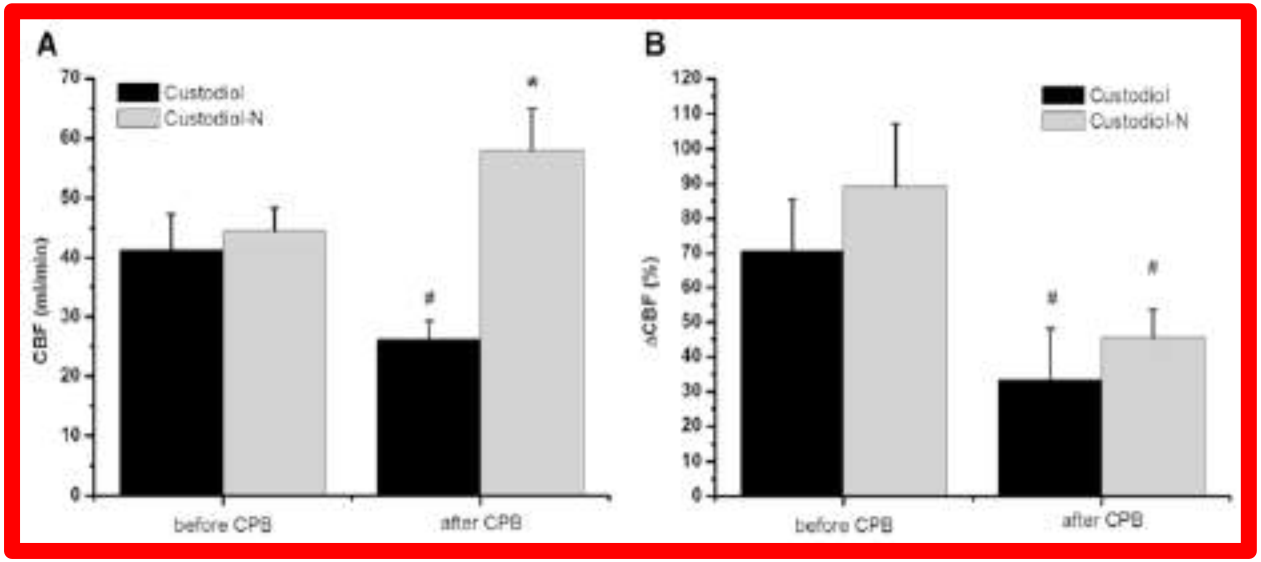
Coronary blood flow was measured on the left an- terior descending (LAD) coronary artery with a peri- vascular ultrasonic flow probe) and

endothelium-independent vasodilatation after admin-istration of sodium-nitroprusside (SNP, 10−4 mol).

Endothelium-dependent coronary vasodilatation was assessed after intracoronary admin- istration of a single bolus of acetylcholine (ACh, 10−7 mol

Myocardial contractility characterized by the load-independent indexes Ees (slope of end-systolic pressure-volume relationship (ESPVR) and preload recruitable stroke work (PRSW)





(Custodiol-N)

superior cardiac and endothelial protection compared to Custodiol

Comparison of renal perfusion solutions during thoracoabdominal aortic aneurysm repair

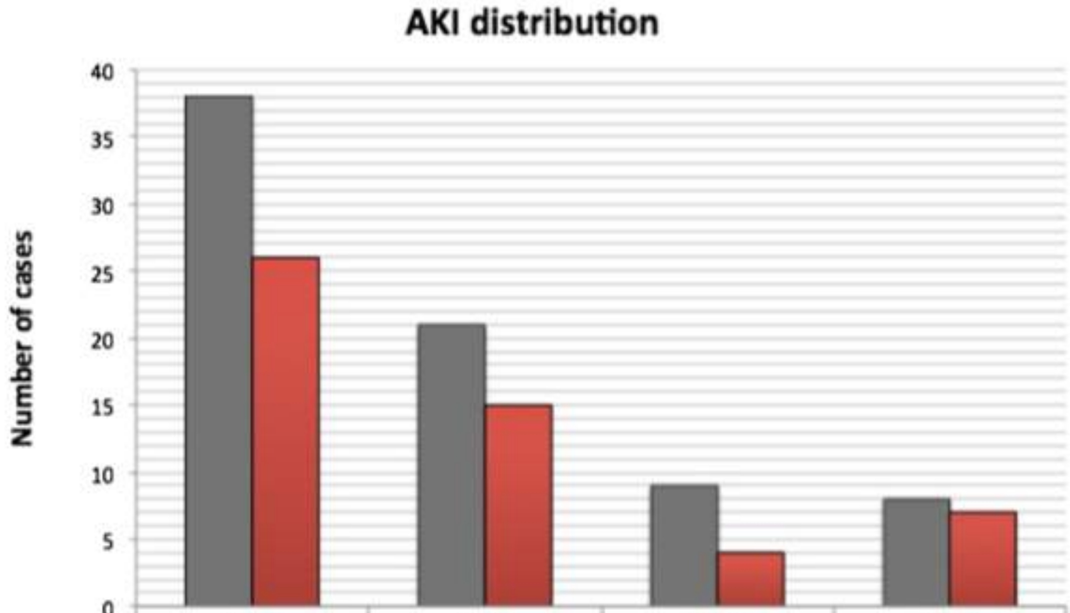
Yamume Tshomba, MD,[a] Andrea Kahlberg, MD,[a] Germano Melissano, MD,[a] Giovanni Coppi, MD,[a] Enrico Marone, MD,[a] Denise Ferrari, MD,[a] Rosalba Lembo, MD,[b] and Roberto Chiesa, MD,[a] *Milan, Italy*

JOURNAL OF VASCULAR SURGERY
March 2014

Table I. Main characteristics of lactated Ringer's solution and Custodiol solution

	Ringer's lactate solution, mmol/L	*Custodiol solution, mmol/L*
Sodium chloride	130.0	15.0
Potassium chloride	4.0	9.0
Magnesium chloride · 6 H_2O	0.0	4.0
Histidine hydrochloride · H_2O	0.0	18.0
Histidine	0.0	180.0
Tryptophan	0.0	2.0
Mannitol	96.4[a]	30.0
Calcium chloride · 2 H_2O	2.7	0.015
Sodium lactate	28.0	0.0
Potassium hydrogen 2-ketoglutarate	0.0	1.0
Methylprednisolone	125 mg/L[a]	0
Osmolality	281 mOsm/L[a]	310 mOsm/L
pH (at 4°C)	6.21[a]	7.4-7.45

111 case
2008-2011



	All AKIs	AKI I	AKI II	AKI III
Ringer	38	21	9	8
Custodiol	26	15	4	7

Abbreviations: AKI= Acute Kidney Injury

Fig 1. Acute kidney injury (*AKI*) distribution in Custodiol and lactated Ringer's groups.

The use of Custodiol was safe and provided improved perioperative renal function compared with lactated Ringer's solution.

Del- Nido

History and Use of del Nido Cardioplegia Solution at Boston Children's Hospital

Gregory S. Matte, BS, CCP, LP, FPP; Pedro J. del Nido, MD

Department of Cardiac Surgery, Boston Children's Hospital, Boston, Massachusetts

JECT. 2012;44:98–103
The Journal of ExtraCorporeal Technology

Guest Editorial

Table 1. Composition of cardioplegia solutions.

	Conventional cardioplegia	del Nido cardioplegia
Carrier	5% dextrose in water 1000 ml	Plasma-Lyte A 1000 ml
Blood : Clear	4 : 1	1 : 4
KCl	120 mEq (120 mmol) ("high K") 60 mEq (60 mmol) ("low K")	26 mEq (26 mmol)
$NaHCO_3$	30 mEq (30 mmol)	13 mEq (13 mmol)
Mannitol	12.5 g (68.62 mmol)	3.26 g (17.90 mmol)
Lidocaine	0	130 mg (0.55 mmol)
$MgSO_4$	0	16.24 mEq (8.12 mmol)
Estimated final composition		
K	23.50 mmol/L ("high K") 13.61 mmol/L ("low K")	20.44 mmol/L
Mg	0.66 mmol/L	6.30 mmol/L
Ca	1.8 mmol/L	0.45 mmol/L
Lidocaine	0	0.42 mmol/L

Estimated final composition was calculated on the premise of blood electrolyte levels: Potassium 4.0 mmol/L, Magnesium 2.0 mg/dL, Calcium 9.0 mg/dL.

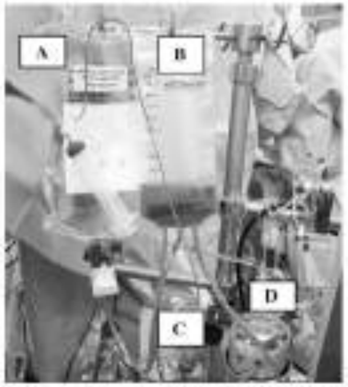
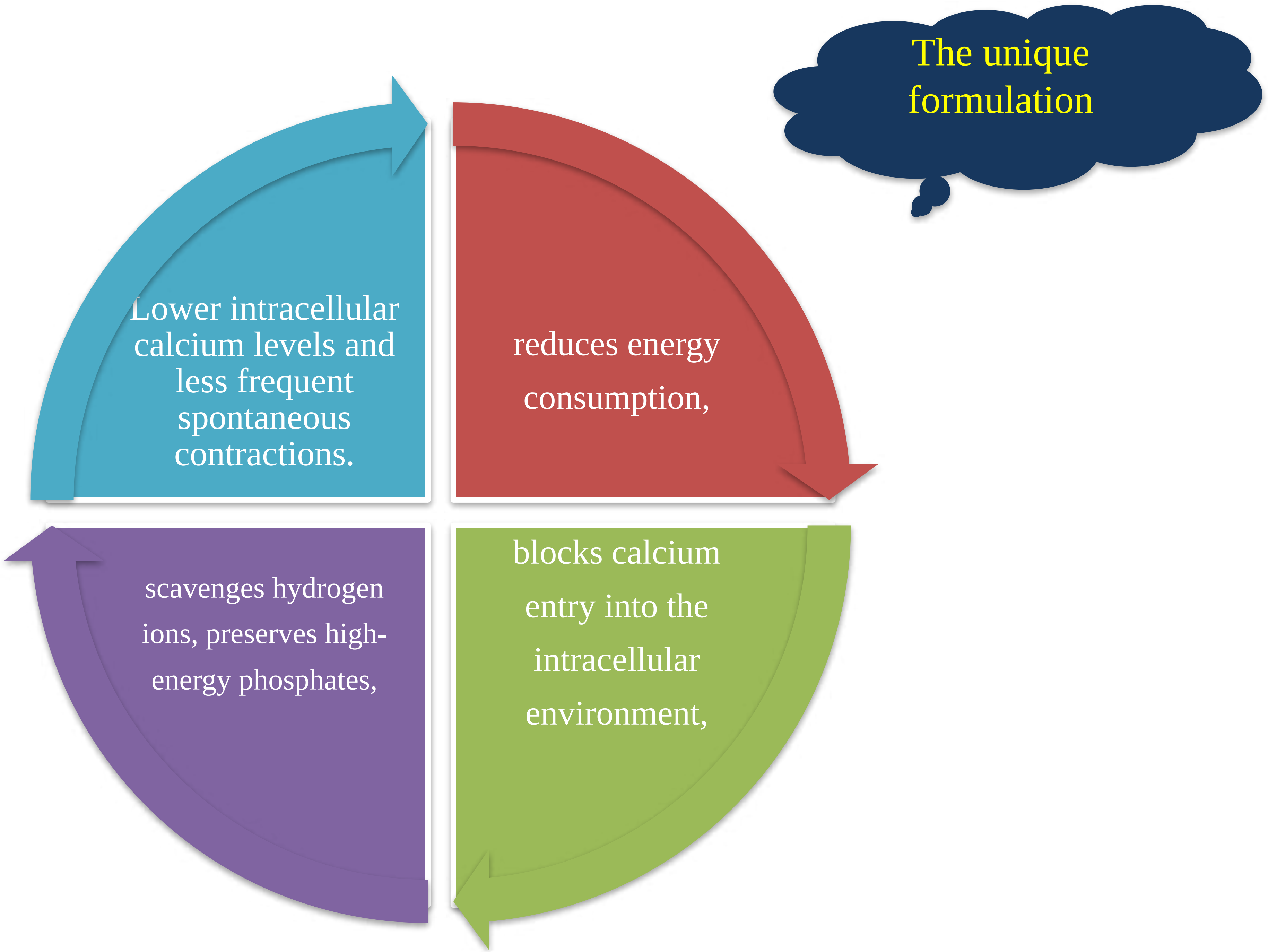


Figure 2. (A) Cardioplegia bag with crystalloid component as provided by pharmacy. (B) Cardioplegia reservoir bag where the 4:1 (crystalloid: blood) components are mixed and recirculated. (C) Stopcock, line, and syringe used to inject bypass circuit blood into the cardioplegia circuit. (D) Cardioplegia roller head.

a single 20-mL/kg dose antegrade at 8– 12C through a recirculating delivery system

Table 3. Cardioplegia calculation for a 50-kg patient.

- 50 kg × 20 mL/kg = 1000-mL cardioplegia dose volume
- 1000-mL dose volume + 150-mL prime volume = 1150-mL total system volume
- 1150-mL total system volume/5 = 230-mL blood component volume
- (1000-mL dose volume + 25-mL minimum reservoir volume) – (230-mL blood component volume) = 795-mL crystalloid cardioplegia volume in the reservoir before the addition of blood that will result in the proper 4:1 mixture for this 50-kg patient
- The perfusionist will have the proper dose amount and mixture for this patient by recirculating 795 mL in the cardioplegia reservoir before bypass and then adding 230 mL of patient whole blood once on bypass. Once the 1000-mL cardioplegia dose is given, the user would be left with the minimum operating level of 25 mL in the cardioplegia reservoir.


The unique formulation
Lower intracellular calcium levels and less frequent spontaneous contractions.
reduces energy consumption,
blocks calcium entry into the intracellular environment,
scavenges hydrogen ions, preserves high-energy phosphates,

Original Paper

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Short-term outcomes in adult cardiac surgery in the use of del Nido cardioplegia solution

Takeyoshi Ota,[1,2] Halit Yerebakan,[1] Robert C Neely,[1] Linda Mongero,[1] Isaac George,[1] Hiroo Takayama,[1] Mathew R Williams,[1,3] Yoshifumi Naka,[1] Michael Argenziano,[1] Emile Bacha,[1] Craig R Smith[1] and Allan S Stewart[1,4]

52 ± 14 min vs. 60 ± 16 min (p<0.01), respectively. Postoperative inotropic support was required in 11 patients (20.4 %) in the del Nido group and 13 patients (24.1 %) in the conventional group (p=0.82) with no statistical difference. No patient required a postoperative intra-aortic balloon pump and in-hospital mortality was 0% in both groups. There was

Short-term outcomes in adult cardiac surgery using del Nido solution were acceptable and comparable to conventional multi-dose whole blood cardioplegia.

J Thorac Cardiovasc Surg. 2018 Mar;155(3):1011-1018. doi: 10.1016/j.jtcvs.2017.09.146. Epub 2017 Nov 13.

The use of del Nido cardioplegia in adult cardiac surgery: A prospective randomized trial.

Ad N[1], Holmes SD[2], Massimiano PS[3], Rongione AJ[3], Fornaresio LM[2], Fitzgerald D[4].

METHODS: Adult first-time coronary artery bypass grafting (CABG), valve, or CABG/valve surgery patients requiring cardiopulmonary bypass (CPB) were randomized to del Nido cardioplegia ($n = 48$) or whole blood cardioplegia ($n = 41$). Primary outcomes assessed myocardial preservation. Troponin I was measured at baseline, 2 hours after CPB termination, 12 and 24 hours after cardiovascular intensive care unit admission. Alpha was set at $P < .001$.

CONCLUSIONS: Evidence from this study suggests del Nido cardioplegia use in routine adult cases may be safe, result in comparable clinical outcomes, and streamline surgical workflow. The trend for troponin should be investigated further because it may suggest superior myocardial protection with the del Nido solution.

Review

Perfusion

del Nido cardioplegia in adult cardiac surgery - scopes and concerns

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George Jose Valooran,[1] Shiv Kumar Nair,[1]
Krishnan Chandrasekharan,[1] Rahul Simon[2] and Cyril Dominic[2]

Table 3. Studies comparing DNP with the conventional CP techniques.

Study (year of publicaton)	Type of study	N	Study Population	Study Group
Mick et al. (2015)	Propensity matched study	195	Isolated valve surgery –Mitral/Aortic	DNP vs Buckberg solution
Yerebakan et al. (2014)	Retrospective study	88	CABG in AMI	DNP vs WB
Sorabella et al. (2014)	Retrospective study	113	Elderly undergoing re-operative valve surgery	DNP vs WB
Loberman et al. (2014)	Propensity matched study	171	CABG, Valve, CABG+Valve	DNP vs WB

DNP: del Nido cardioplegia; CPB: cardiopulmonary bypass; CABG: coronary artery bypass grafting; AMI: acute myocardial infarction; AVR: aortic valve replacement; MVR: mitral valve replacement; WB: whole blood; CP: cardioplegia; CKMB: myocardial creatinine kinase.

Lower CPB and AOX

Low defibrilator need

Low Af incidence

Higher CPKMB

Though the concerns in using a single-dose, long- acting, extracellular CP solution like DNP for achieving a depolarized ischemic arrest in the adult heart are justified, the initial reports of its use are encouraging, as already outlined

Although the proposed benefits of DNP are attractive, the lack of a well-structured protocol for its use is a major limitation,

The safety margin of DNP for use in the ischemic myocardium has not been well established to date.

The need for a hot shot or additional calcium-chelating agent, like citrate phosphate dextrose, during reperfusion after single-dose CP, such as DNP, is another area which requires further investigation

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Myocardial Protection Using del Nido Cardioplegia Solution in Adult Reoperative Aortic Valve Surgery

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Composition of Whole Blood cardioplegia vs. del Nido Cardioplegia

Similar outcome

Less cardioplegia volume

Comparison of del Nido cardioplegia and St. Thomas Hospital solution – two types of cardioplegia in adult cardiac surgery

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ST cardioplegia	
Na^+	110 mmol/l
K^+	16 mmol/l
Mg^{2+}	16 mmol/l
Ca^{2+}	1.2 mmol/l
$NaHCO_3^-$	10 mmol/l
DN cardioplegia	
Mannitol	20%, 16.3 ml, 3.26 g
Magnesium sulfate	50%, 4 ml, 2 g
Sodium bicarbonate	8.4%, 13 ml, 13 mEq
Lidocaine	1%, 13 ml, 130 mg
Potassium chloride (2 mEq/ml)	13 ml, 26 mEq

Variable	Procedure	ST	DN	*P*-value
Number of grafts	CABG	3.8 ±0.67	4 ±0.62	0.310
Aortic cross clamp time, mean ± SD [min]	Total	133.56 ±35.66	110.15 ±36.84	0.012
	DVR	152.11 ±24.99	128.77 ±22.74	0.034
	CABG	128.28 ±37.11	104.22 ±38.50	0.043
Cardiopulmonary bypass time, mean ± SD [min]	Total	179.81 ±42.36	158.60 ±39.[illegible]	0.041
	DVR	198.78 ±27.87	177.69 ±17.[illegible]	0.040
	CABG	172.83 ±46.07	143.85 ±45.[illegible]	0.043
Inotropic usage, *n* (%)	Total	[illegible]	[illegible]	0.548
	DVR	14 (87.5)	12 (85.7)	0.885
	CABG	12 (35.2)	11 (30.5)	0.817
IABP usage, *n* (%)	Total	1 (2)	0	0.314
	DVR	0	0	1.000
	CABG	1 (2.9)	0	0.300
In-hospital mortality, *n* (%)	Total	1 (2)	0	0.314
	DVR	0	0	1.000
	CABG	1 (2.9)	0	0.300

- Shorter cross clamp and CPB times,

- Reduces cardioplegia dosage,

- Better myocardial protection in terms of LVEFpreservation,

-with a safety profile comparable to ST cardioplegia.

Najjar et al. Journal of Cardiothoracic Surgery (2015) 10:176
DOI 10.1186/s13019-015-0383-x

Journal of Cardiothoracic Surgery

RESEARCH ARTICLE Open Access

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Feasibility and safety of continuous retrograde administration of Del Nido cardioplegia: a case series

Marc Najjar[†], Isaac George[*†], Hirokazu Akashi, Takashi Nishimura, Halit Yerebakan, Linda Mongero, James Beck, Stephen C. Hill, Hiroo Takayama and Mathew R. Williams

Redo CABG

DN cardioplegia's administration in a continuous retrograde fashion with a patent IMA is believed to provide adequate myocardial protection while avoiding injuring the IMA through dissection and clamping.

Comparison Del Nido and St. Thomas cardioplegia effect on clinical outcomes of adult patients undergoing complex heart valve surgery

Ghavidel et al. 2016

Conclusion:

Del- Nido for aduld cardiac complex surgeries is

Safe

Effective

Time saving

Comparable with standard cardioplegia solution

Cardioplegic Blood

Comparison of the Effects of Procaine Hydrochloride and Lidocaine in Cardioplegic Solution, on Arrhythmia after Opening of Aortic Valve in Coronary Artery Bypass Graft Surgery

Alireza A. Ghavidel [1], Hooman Bakhshandeh [2], Ziae Totonchi [3], Nasser Hadavand [4], Soheila Sadeghi [5*]

RCT

100 patient

CABG

primary end point

Post –op

Arrythmia

Cardioplegic Blood Shaheed Ghazi co. Tabriz/Iran

Kcl	**44 Meq**
Nacl	147 Meq
Mg	64 Meq
Ca	4.5 Meq
Osmolarity	300-320
PH	7.30-7.40

50 ml in 1000 Ringer 4 degree of celsius

The spontaneous return of heart rate was higher (P-value = 0.02, 64% for procaine hydrochloride and 42% for lidocaine

Required values for lidocaine and magnesium (P = 0.02) and inotrope (P = 0.04) were also relatively lower

Cardioplegic solution volumes were slightly higher in procaine hydrochloride.

It does not have any significant effects on decreasing arrhythmia after opening of the aortic valve and is not preferable to the cardioplegic solution containing lidocaine


Thank you