

Outpatient LAST and the Discovery of Lipid Resuscitation



SAMBA 2024
Frontier Lecture:
 Friday May 3
 Savannah, GA.

Guy Weinberg, MD
Professor of Anesthesiology
University of Illinois, Chicago
@lipidguy
he/him/his

SOCIETY FOR
SAMBA **ULATORY**
ANESTHESIA

Outpatient • Office Based • Non-Operating Room

1

Disclosures

- I have the following financial interests or conflicts to disclose:
 - ResQ Pharma, Inc
 - – Officer and Shareholder
 - Will discuss off-label use of FDA-approved medication



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Objectives

After this lecture, participants will be able to:

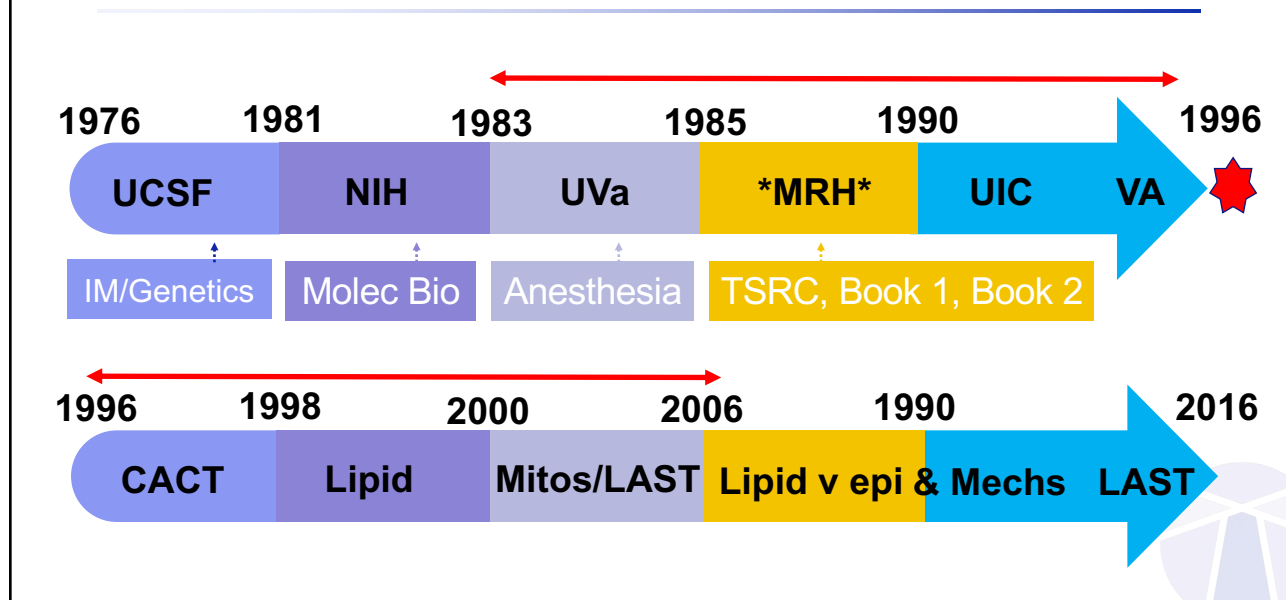
- **Employ methods to mitigate the risk of LAST**
- **Explain mechanisms of lipid resuscitation**
- **Relate an example of translational research in anesthesiology**

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Academic Timeline



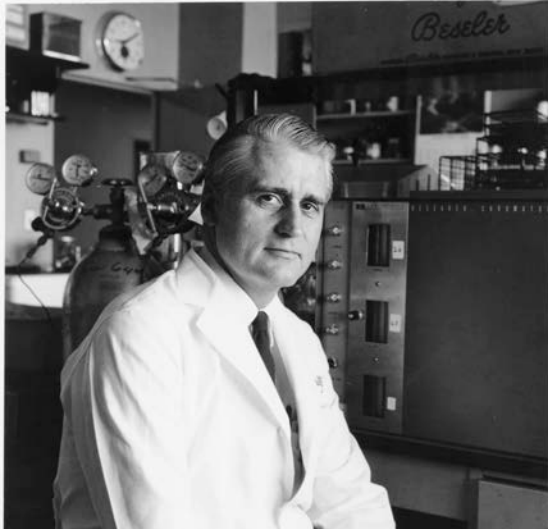
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Comparative Career Arcs



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UCSF 1976-1979 (IM → Med Genetics)



Lloyd Hollander "Holly" Smith

Hemochromatosis

These discussions are selected from the weekly staff conferences in the Department of Medicine, University of California, San Francisco. Taken from transcriptions, they are prepared by Drs. David W. Martin, Jr., Associate Professor of Medicine, and Robert C. Siegel, Associate Professor of Medicine and Orthopaedic Surgery, under the direction of Dr. Lloyd H. Smith, Jr., Professor of Medicine and Chairman of the Department of Medicine. Requests for reprints should be sent to the Department of Medicine, University of California, San Francisco, CA 94143.

DR. SMITH:* The topic for discussion at Medical Grand Rounds today will be that of hemochromatosis. The case summary will be given by Dr. Guy Weinberg.

DR. WEINBERG:† The patient is a 43-year-old white man who presented in the fall of last year to the Metabolic Clinic with the chief complaint of impotence. Five years ago the patient noted the onset of difficulty of achieving and maintaining an erection, as well as a reduced sex drive.



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Black Swan



Black Swans: rare high-impact events account for many major scientific discoveries –
Nassim Taleb,
adapted from Wikipedia

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1983

Hillary Don



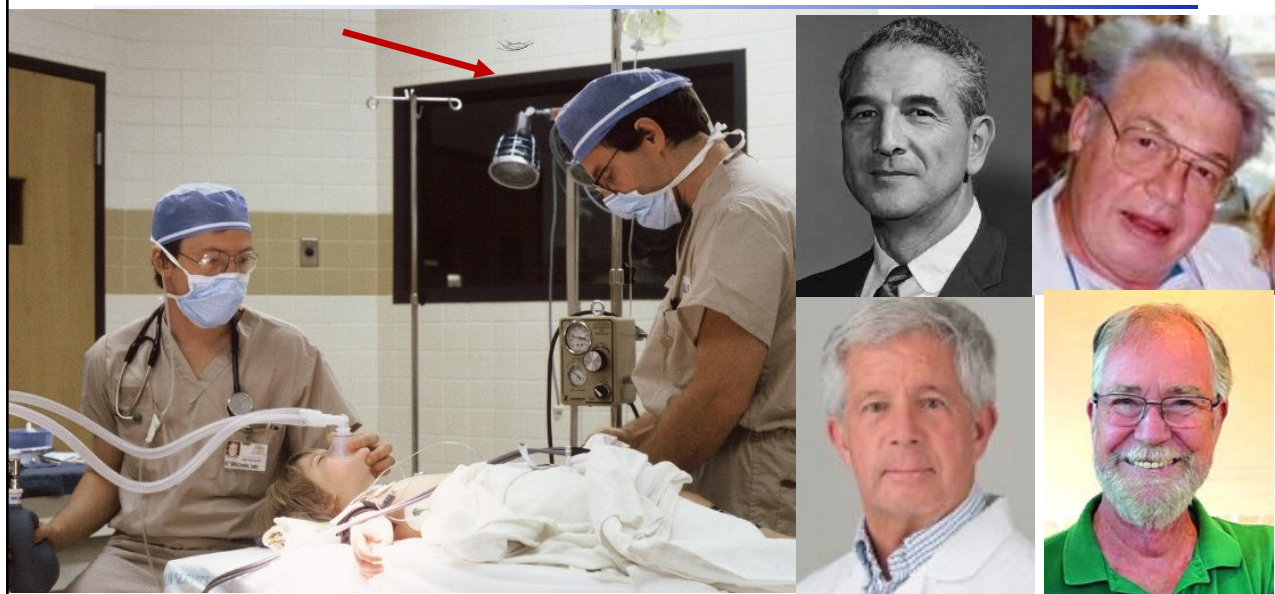
Lydia Cassorla.



Bob Epstein

10

University of Virginia, 1983



11



Molecular Mechanisms of General Anesthesia, Telluride CO, 1993

12



Peter Geldner



Index Case, 1996

Case Reports

**Malignant Ventricular Dysrhythmias
in a Patient with Isovaleric Acidemia
Receiving General and Local
Anesthesia for Suction Lipectomy**

Journal of Clinical Anesthesia 9:668–670, 1997

Guy L. Weinberg, MD,* Charles E. Laurito, MD,†
Peter Geldner, MD,‡ Bernard H. Pygon, MD,*
Barbara K. Burton, MD§

Department of Anesthesiology, University of Illinois College of Medicine, Chicago, IL.

- 20yo, bupivacaine 22mg, SQ.
- 3RD degree block, VT
- Severe carnitine deficiency**



Bud Pygon



Barbara Burton

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Is There a Carnitine Connection?

- Does carnitine deficiency predispose to LAST?
- Is carnitine linked to bupivacaine toxicity?
- Does bupivacaine interfere with carnitine?
- What does carnitine do????

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June Palmer

Getting lucky



Charles Hoppel

CN(C)CC(O)CC(=O)[O-]



Biochemical Properties of Subsarcolemmal and Interfibrillar Mitochondria Isolated from Rat Cardiac Muscle*

(Received for publication, July 29, 1977)

JUNE W. PALMER,[‡] BERNARD TANDLER, AND CHARLES L. HOPPEL[§]

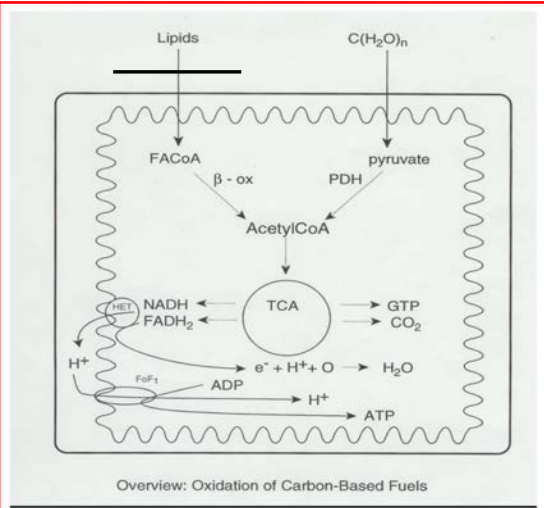
From the Veterans Administration Hospital and Departments of Pharmacology and Medicine, School of Medicine, and the Department of Oral Biology and Medicine, School of Dentistry, Case Western Reserve University, Cleveland, Ohio 44106

REQUIRED FOR FATTY ACID TRANSPORT INTO MITOS

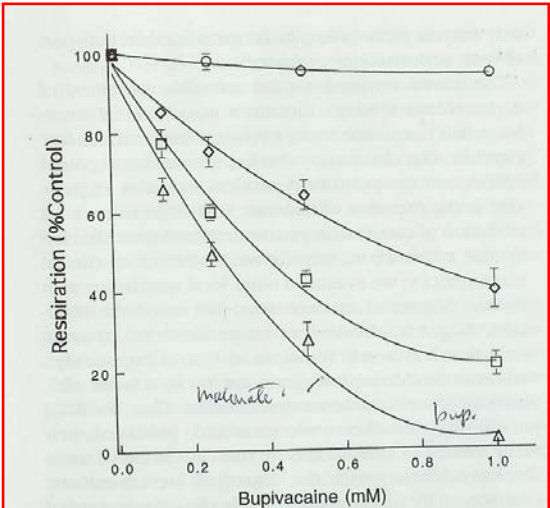
Free Fatty Acids = Heart's Preferred Fuel

15

Bupivacaine Inhibits Acylcarnitine Transport



Overview: Oxidation of Carbon-Based Fuels



Weinberg, G, Palmer J, VadeBoncouer, T and Hoppel, C. Anesthesiology 2000

16

Carnitine-Deficient Animal

- Carnitine deficient rat: no luck
- PB Corr says fatty acyl-carnitines = arrhythmias
- So my reasoning was....

IF BUPIVACAINE BLOCKS FATTY ACID MITO UPTAKE, INCREASING CELLULAR FATTY ACIDS SHOULD WORSEN TOXICITY, BUT NO...

THE OPPOSITE OCCURS!

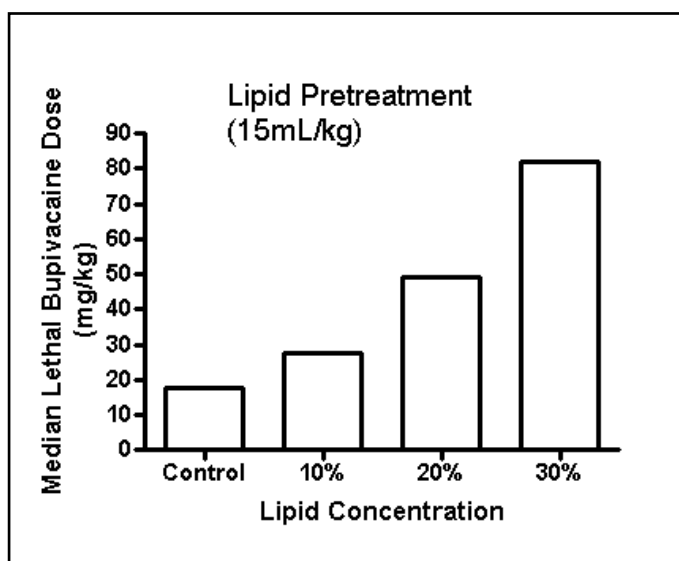


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Lipid Pretreatment Protects from LAST

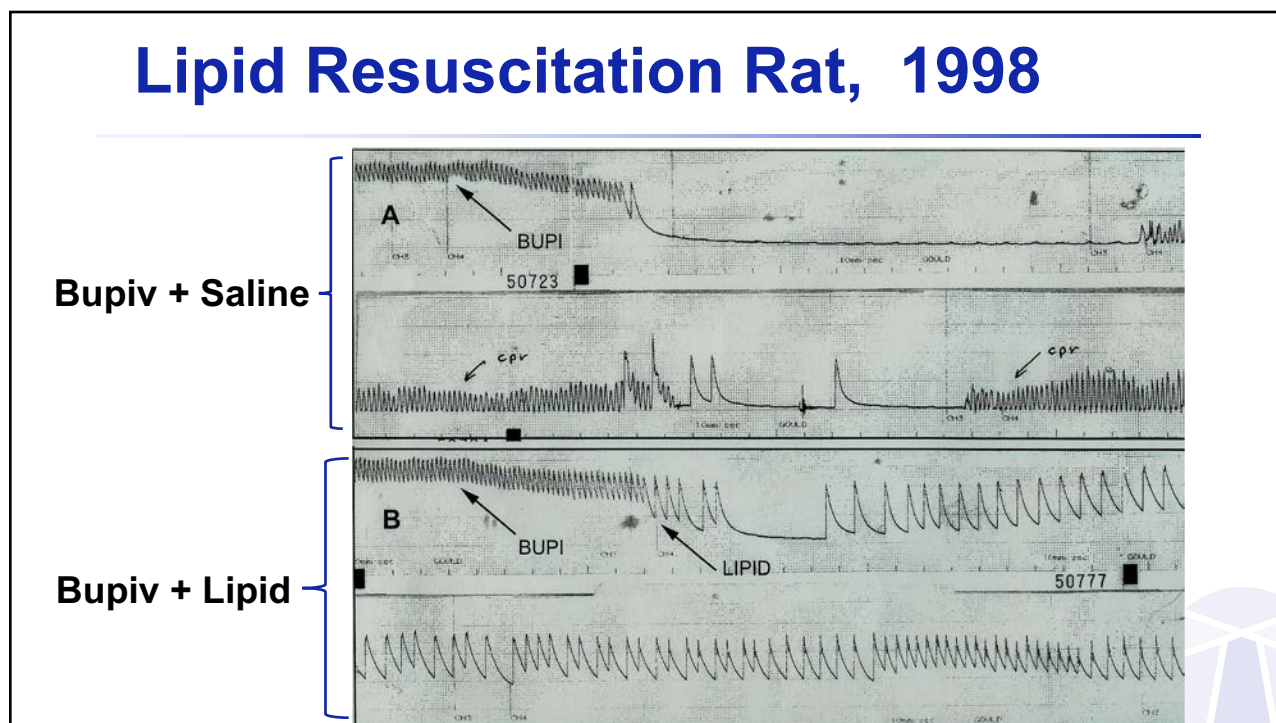


David Visintine



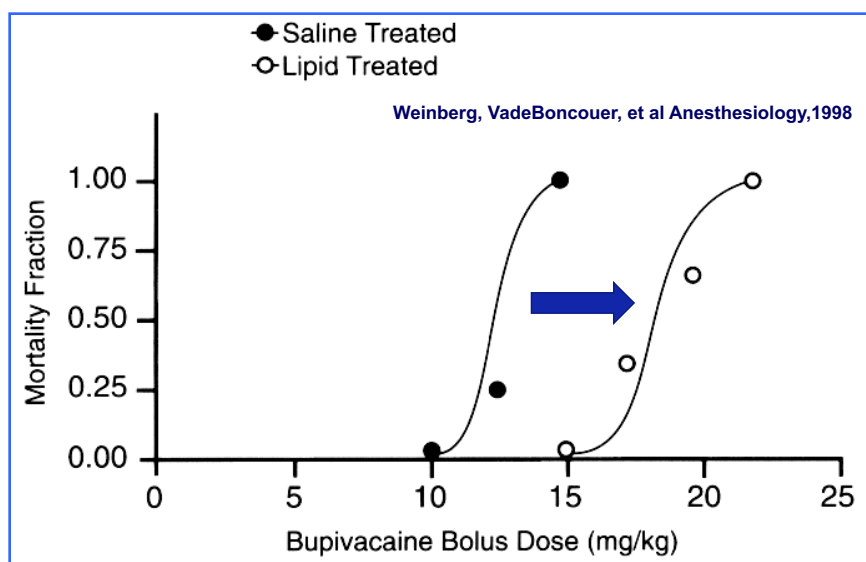
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Lipid Resuscitation Rat, 1998



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Dose-Response Resuscitation with Lipid

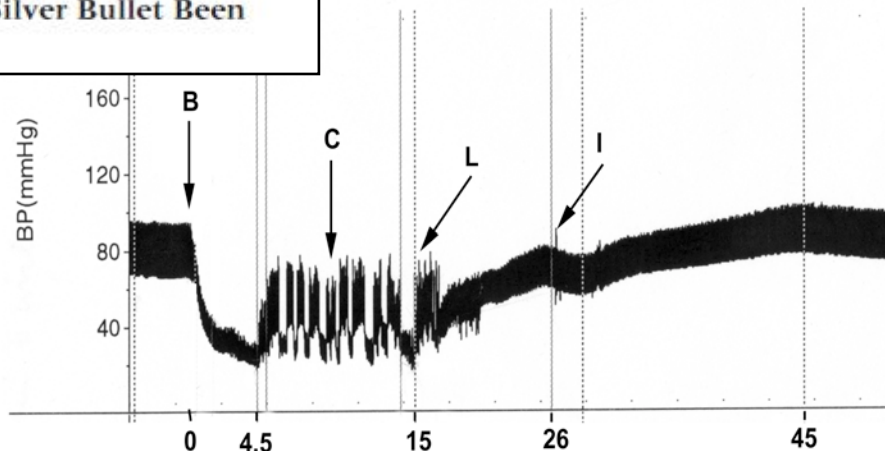


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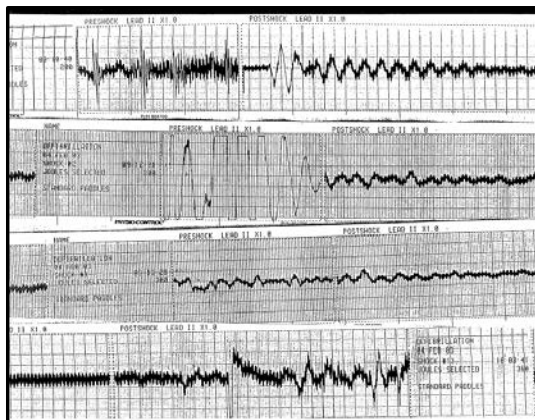
Lipid Resuscitation Dog, 2003

Lipid Reversal of Bupivacaine Toxicity: Has the Silver Bullet Been Identified?

**Groban &
Butterworth
RAPM, 2003**



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Consent Form
Authorization for Donation of Anatomical Gifts

1. I authorize LifeShare of the Carolinas to utilize such personnel and services as in their judgment may appear necessary for the purposes for which this Authorization is granted. Any persons or organizations so utilized may rely on this authorization.

2. I, as next-of-kin of the above named decedent, in the hope that I may help others, hereby donate and permit the removal of the following organs and tissues: (ENTER YES OR NO)

☐ Heart	☐ Kidney	☐ Liver	☐ Lungs	☐ Pancreas	☐ Intestines
☐ Heart for Valves	☐ Whole Eyes	☐ Leg Vains	☐ Whole Body	☐ Corneas	☐ Other

*with
Anatomical
3*

Heart for Valves

Whole Eyes

Corneas

Bone Assoc.

tissue of

lower extrem

*Donor's
Legs*

☐ Bone (Associated Tissue of upper extremities)

☐ all persons or institutions for transplantation into other persons or for determined that the donated gifts are not able to be transplanted. YES ☐ NO ☐

☐ are Carolinas and other persons or organizations responsible for the

☐ lymph nodes and spleen) needed for laboratory tests to determine

☐ tests, including but not limited to, cultures for infection, organ function

☐ the organs and tissues for transplantation.

☐ test results will be reported to the State Health Director as required by

☐ stored, and that in the case of brain death, artificial support will be

☐ family member of the same or prior class, for the removal of the

☐ the: other parent, adult brother or sister, guardian).

10. I understand that if bone is to be donated an unlimited autopsy may be performed, and I have no objections to this.

Signature: _____

11. I understand that no costs associated with evaluation, management, and/or surgical retrieval will be incurred by the donor's family or estate. Any expenses incurred up until death/determination for brain death will continue to be the responsibility of the estate.

12. This document has been explained to me by _____

13. I make this gift voluntarily and with full understanding of this document.

- 32 yo ASA Class I male; ORIF 4th metacarpal shaft
- Trans-arterial axillary block with 40mL 0.5% ROPIVACAINE with epi
- Intercostal brachialis, 5mL
- General Tonic-Clonic Seizure -> bradycardia --> V Fib
- Code Blue: intubation, ACLS protocol X 2 hour

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Clinical Translation, 2006

Anesthesiology 2006; 105:217-8

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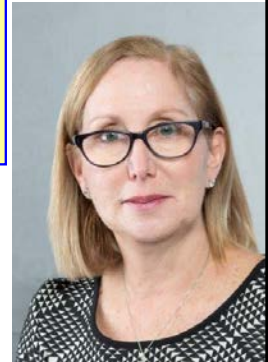
Successful Use of a 20% Lipid Emulsion to Resuscitate a Patient after a Presumed Bupivacaine-related Cardiac Arrest

Meg A. Rosenblatt, M.D.,* Mark Abel, M.D.,† Gregory W. Fischer, M.D.,† Chad J. Itzkovich, M.D.,‡ James B. Eisenkraft, M.D.§

INTERSCALENE BLOCK for rotator cuff repair
20ml Bupivacaine 0.5% - 20ml Mepivacaine 1.5%
30 sec later, SEIZURE (Propofol 50+100mg); 90 sec later CARDIAC ARREST...
CPR: epinephrine, atropine, amiodarone, vasopressin, defibrillation.
PULSELESS VT... Within 15 sec OF LIPID pulse/blood pressure detectable



Meg Rosenblatt saved the day



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More Case Reports Follow

Anesthesiology, 2006, 61, pages 800-801
 doi:10.1111/1517-9552-2044-2006-04780.x

CASE REPORT
Successful resuscitation of a patient with ropivacaine-induced asystole after axillary plexus block using lipid infusion*

R. J. Litz, M. Popp, S. N. Stehr and T. Koch

Anesthesiology, 2007, 62, pages 516-518
 doi:10.1111/1517-9552-2044-2007-05065.x

CASE REPORT
Levobupivacaine-induced seizures and cardiovascular collapse treated with Intralipid®

G. Foxall,¹ R. McCahon,² J. Lamb,³ J. G. Hardman⁴ and N. M. Bedford⁵

Anesthesiology 2007; 55:443-453
 DOI:10.1007/s00191-007-1147-3
 Online published: 3. February 2007
 © Springer Medizin Verlag 2007

Redaktion
 Dr. Peter, München

C. Zimmer - K. Piepenbrink - G. Blett - J. Peters
 Klinik für Anästhesiologie und Intensivmedizin, Universitätsklinikum Essen, Essen

Kardio- und neurotoxische Nebenwirkungen nach akzidenteller intravasaler Bupivacainapplikation
 Therapie mit Lidocain, Propofol

Anesthesiology 2007; 107:516-7

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Lipid Reversal of Central Nervous System Symptoms of Bupivacaine Toxicity

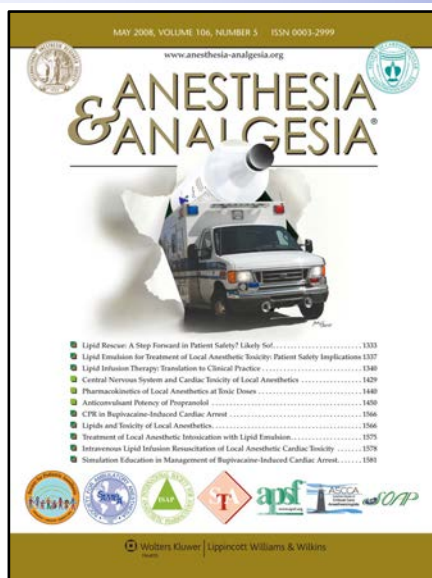
Andrew G. Spence, F.R.C.A., King Edward VII Memorial Hospital, Hamilton, Bermuda. aspen@transact.bm



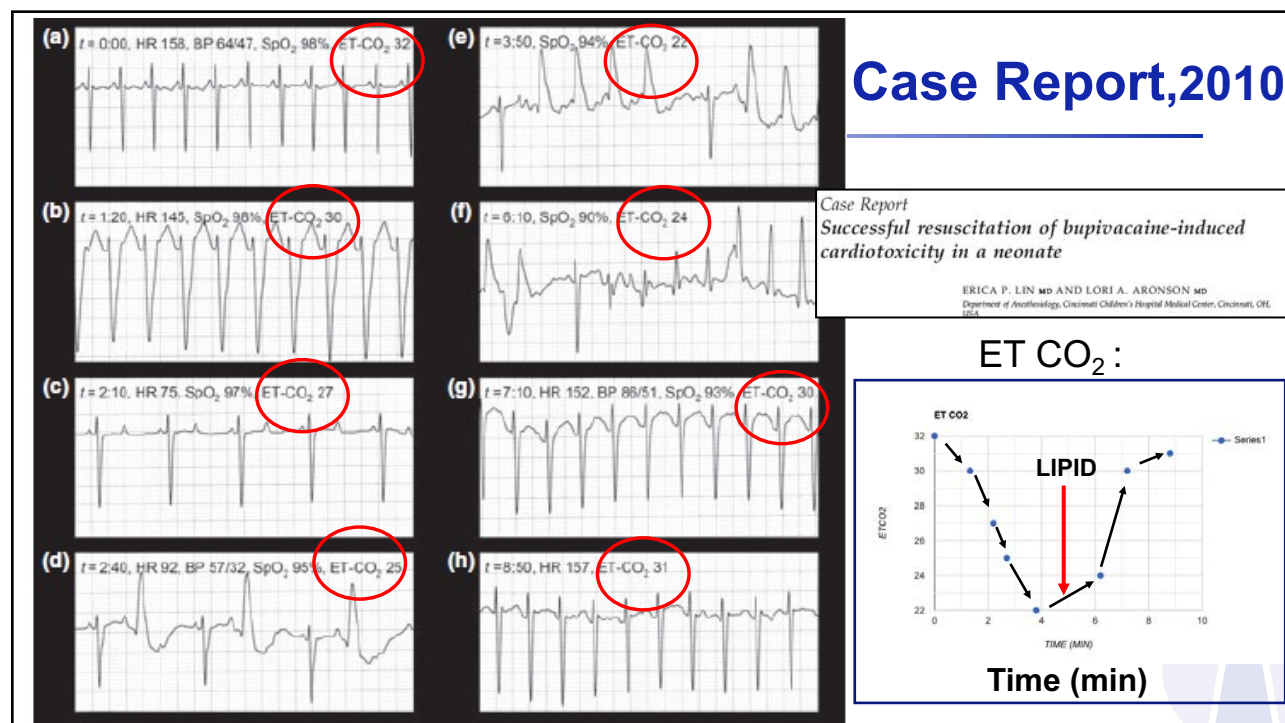
Dr. Rainer Litz

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~2008: 4 cases in AA 4 cases in RAPM

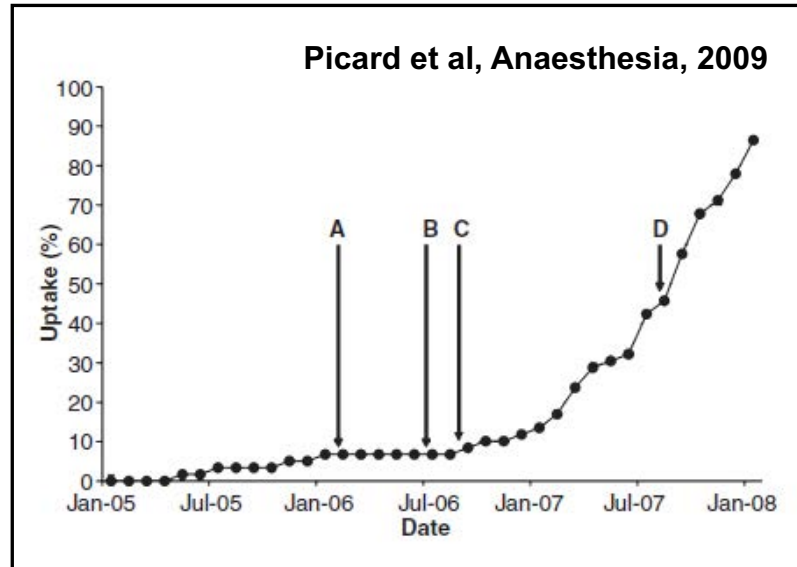


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Lipid in London Hospitals, 2009



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AAGBI & ASRA LAST Advisories, 2010

1 Recognition	Signs of severe toxicity: - Sudden alteration in mental status, severe agitation or loss of consciousness, with or without tonic-clonic convulsions - Cardiovascular collapse: sinus bradycardia, conduction blocks, asystole and ventricular tachyarrhythmias may occur - Local anaesthetic (LA) toxicity may occur some time after an initial injection		
2 Immediate management	- Stop injecting the LA - Call for help - Maintain the airway and, if necessary, secure it with a tracheal tube - Give 100% oxygen and ensure adequate lung ventilation (hyperventilation may help by increasing plasma pH in the presence of metabolic acidosis) - Confirm or establish intravenous access - Control seizures: give a benzodiazepine, thiopental or propofol in small incremental doses - Consider drawing blood for analysis, but do not delay definitive treatment to do this		
3 Treatment	<table border="0"> <tr> <td> IN CIRCULATORY ARREST - Start cardiopulmonary resuscitation (CPR) using standard protocols - Manage arrhythmias using the same </td> <td> WITHOUT CIRCULATORY ARREST - Use conventional therapist to treat - hypotension, - bradycardia, </td> </tr> </table>	IN CIRCULATORY ARREST - Start cardiopulmonary resuscitation (CPR) using standard protocols - Manage arrhythmias using the same	WITHOUT CIRCULATORY ARREST - Use conventional therapist to treat - hypotension, - bradycardia,
IN CIRCULATORY ARREST - Start cardiopulmonary resuscitation (CPR) using standard protocols - Manage arrhythmias using the same	WITHOUT CIRCULATORY ARREST - Use conventional therapist to treat - hypotension, - bradycardia,		




William Harrop-Griffiths
John Picard

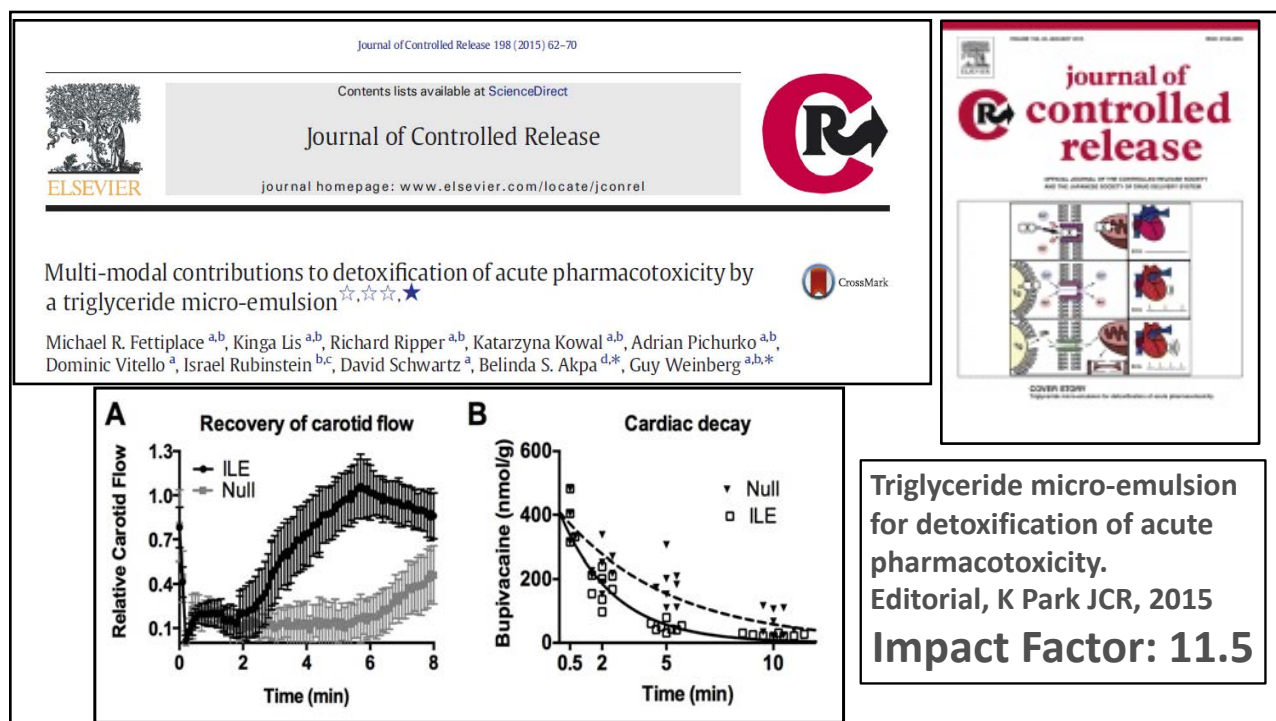
AMERICAN SOCIETY OF
REGIONAL ANESTHESIA AND PAIN MEDICINE

**Practice Advisory on Treatment
of Local Anesthetic Systemic Toxicity**




Rick Rosenquist
Joe Neal

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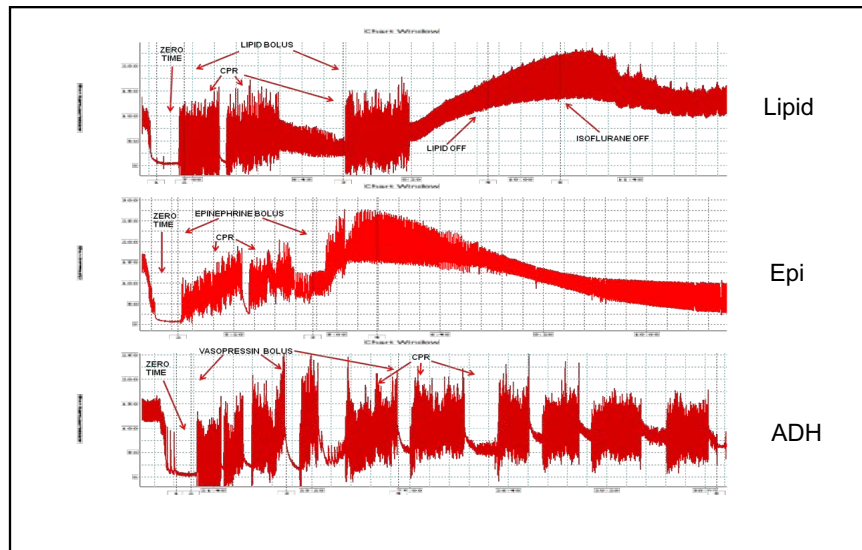
Lipid Accelerates LA Redistribution

- Partitioning + Inotropy = Redistribution
- Primary effect is pharmacokinetic
- PK effect is quick & dynamic (shuttle) not static (sink)
- Other effects occur, too: cytoprotection (RISK, Akt)

A reproducible PK effect

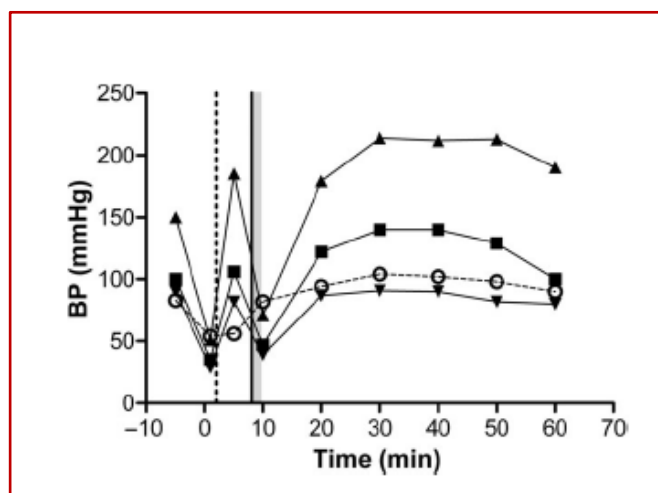
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Lipid vs Pressors in ACLS for LAST



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Same Effect in the Clinical Setting


EMA

TOXICOLOGY

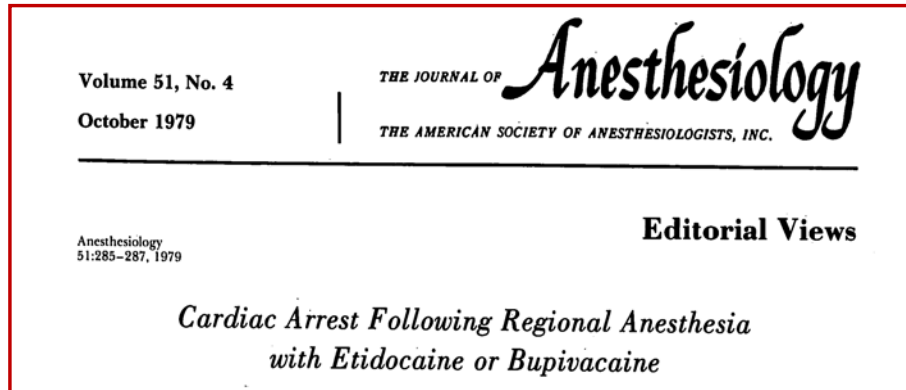
Successful resuscitation from bupivacaine-induced cardiovascular collapse with intravenous lipid emulsion following femoral nerve block in an emergency department

Martyn Harvey,¹ Grant Cave,² Giles Chanwai¹ and Tonia Nicholson¹
¹Waikato Hospital, Hamilton and ²Hutt Hospital, Lower Hutt, New Zealand

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Historical Recognition of LAST

Mayer E. The Toxic Effects Following the Use of Local Anesthetics. JAMA, 1924.
43 cases of fatal toxicity involving cocaine or procaine



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ASRA Working Group, 2022

Overarching Theme: Improving Patient Safety

- Members:
- Guy Weinberg, Chair
- Joe Neal, Co-Chair
- Michael Barrington
- Marina Gitman
- Michael Fettiplace

Clinical:

- presentation
- epidemiology

Risk Reduction:

- susceptible patients
- system vulnerabilities

Treatment:

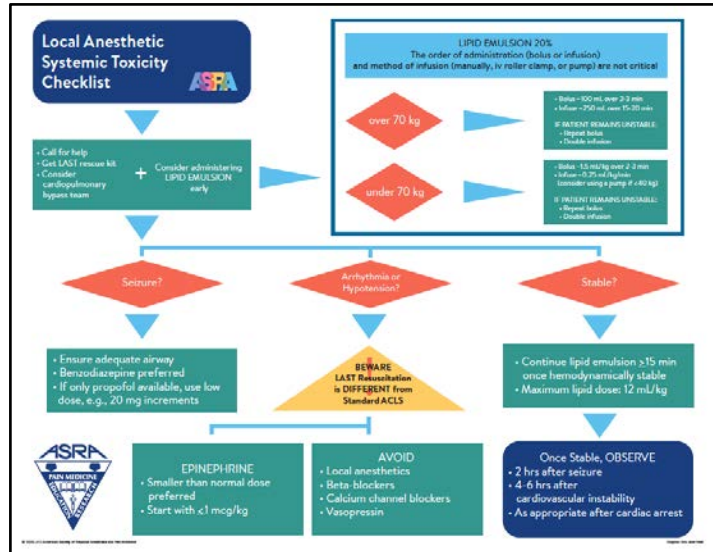
- simple, unambiguous
- cognitive aids

Education:

- beyond anesthesiologists

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ASRA LAST Advisory



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Rate of LAST: Rare....Or Not?

Frequency Estimates Since Mulroy, 2002
(rate = events per 10,000)

• Auroy 2002	1.4	
• Orebaugh 2012	11	v 0/9096 with US
• Sites 2012	0.8	with ultrasound guidance
• Barrington 2014	8	Odds Ratio 0.2 for US
• Liu 2015	0.4	2009-2014; 3/80,000; 2 w US
• Heinonen 2015	3.6	after eliminating epidurals
• Morwald 2017	18	
• Rubin 2018	18	

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Cardiac History in Reports of Lipid Rescue from LA Toxicity
= Susceptible Groups:

Rosenblatt: prior MI, RBBB and LAHB, angina
Litz I: LABB, Stokes attacks, MVR, TVR
Warren: S/P MI, RBBB, HTN
Foxall: stable angina, QwV1-3, PAC
Litz II: CAD, MVR
Smith: S/P CABG, 2 stents

Note the unintended benefits of LipidRescue Resuscitation:
More reports; clearer definition of clinical phenotype of LA toxicity.
More insights into underlying mechanism and difference from lab models

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Known Susceptible Populations:

- **<6 months (PRAN) = >6X increase (Polaner)**
- **Elderly, Frail**
- **Sarcopenia**
- **Cardiac Dz**
- **Na Channel-blocker**
- **Mitochondrial Myopathy**
- **NB: SMALL PATIENTS AT GREATER RISK**

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Most Recent Update on Susceptibility

Local anesthetic dosing and toxicity of adult truncal catheters: a narrative review of published practice

Brittani Bungart^{1,2}, Lana Joudeh^{1,2}, Michael Fettiplace^{1,2}
Bungart B, et al. *Reg Anesth Pain Med* 2023;0:1–14

Box 1 Risk factors for local anesthetic systemic toxicity identified in catheters

Low weight

High weight-based dose

- ⇒ Multiple/bilateral catheters.
- ⇒ Prolonged duration (>72 hours).
- ⇒ Breakthrough doses.

Hypoalbuminemia

Albumin displacing drugs (amitriptyline).
Cardiac surgery/ischemic heart disease.
Liver failure/resection.
Cytochrome P450 inhibiting medications.

Conclusion and remaining questions

In conclusion, we investigated the use of bupivacaine and ropivacaine in PVB and TAP catheters across the literature and found frequent use of doses in excess of the package insert upper limit recommendations. We also identified cumulative dose in adult patients as a consistent risk factor for toxicity, contrary to prior meta-analysis⁶ and expert opinion.^{4,5}

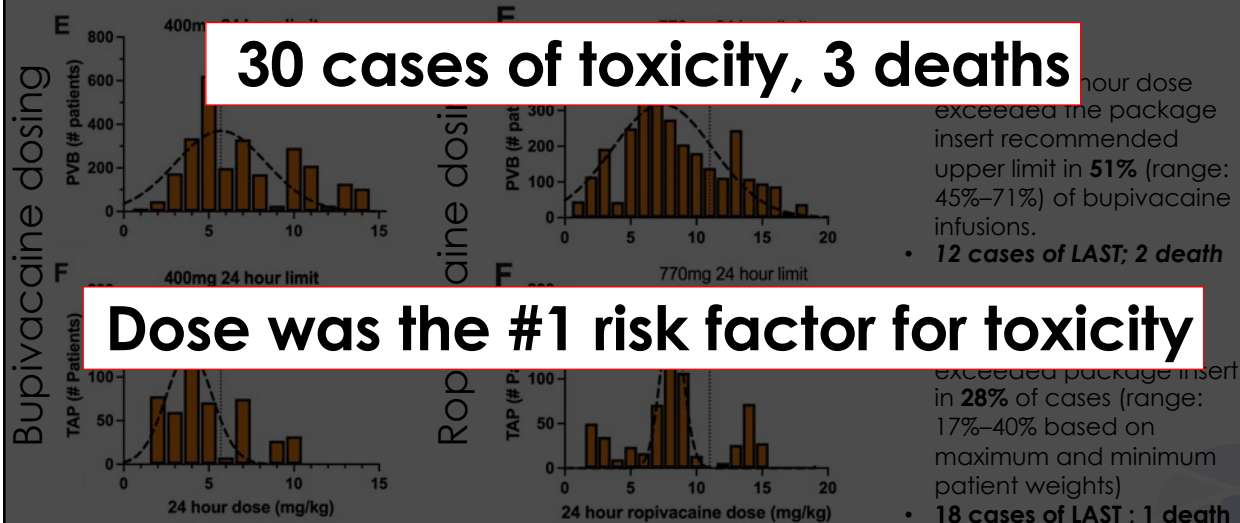
© 2022 AMERICAN SOCIETY OF ANESTHESIOLOGISTS.

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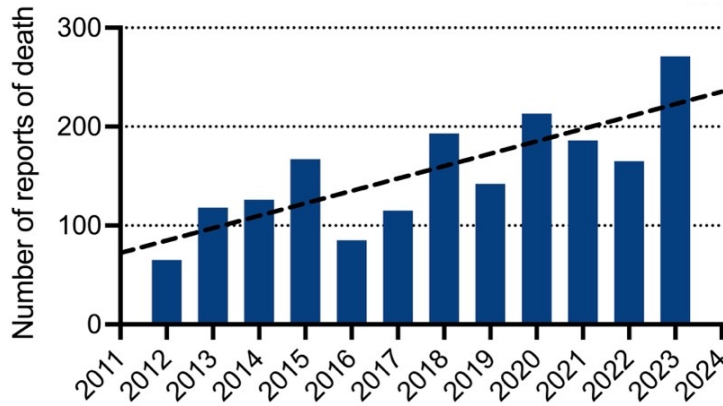
Dose as a risk factor for toxicity...in catheters

30 cases of toxicity, 3 deaths

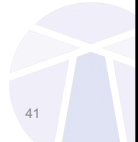


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Reports of LAST Fatality Increase: FDA Adverse Event Reporting System



Reports of local anesthetic associated death 2012-2023 increased approximately 15% per year relative to baseline level in 2011 (Fit line with intercept of $y=80$ at 2011 and slope of 12.55 reports per year, $R^2 = 0.62$)



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LAST: Evolving Clinical Context

Non-anesthesia providers: ~50%

Out of hospital: 20%

Out of OR: 30%

Delayed >10min (50%) or CV 1st

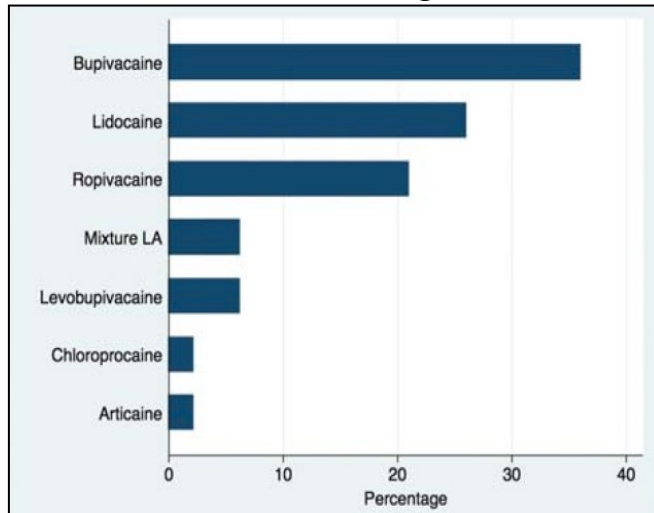
And maybe the biggest surprise.....



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Different 'Leader' in LAST

Gitman and Barrington, 2018



Since 2018:

Lidocaine 60%:

(alone 40%, combined 20%)

Ropivacaine 10%

Bupivacaine 10%

Topical and field blocks

Nasal/oral/airway: 20%

Lidocaine infusion

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	<i>block</i>	<i>drug</i>	<i>dose</i>	<i>timing</i>	<i>comment</i>	<i>Dr</i>	<i>result</i>
	fem	bup	200	Immed	.675%	A	Died
	SQ	Bup/lid	220,450	30m	IHR	S	Died
	SQ Klein's	Bup/lid	70, 880	30m	Cocaine; phentermine	S	Survived impaired
	SQ	bup	100	<10m	wrist fracture	S	Died
	SQ	bup	50	10m	lipoma	S	Died
	SQ Klein's	bup	22	10m	Cn def	S	Recov
	caudal	bup	25 (2/k)	Immed	infant	A	Recov
	axillary	rop	200	immed	transart	A	Died

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Lidocaine Toxicity and (over)Dosing

Age	Weight (kg)	Dose (mg) Plain	Route	Timing	Provider	ILE
11mo	8.5	"Copious"	Topical	Delayed	Parent	No
48y	79	100	ESP	Immediate	Anesthesiologist	No
42y	57	330	Interscalene + Field	Immediate	Anesthesiologist	Yes
35y	73	2,3,4 mg/min 7136 mg total 226/hr x 31.5hrs	Intravenous	Delayed	Anesthesiologist	No
48y	67	200	Field	Delayed	Surgeon	Yes
22y	56	600	Field	Delayed	Surgeon	Yes
60y	58	800	Posterior tibial	Immediate	Anesthesiologist	Yes/No
47y	64	800	Field	Delayed	Surgeon	Yes
53y	37	600	Field		Cardiologist	Yes
5y		1200	Topical	Delayed	Parent	Yes
7y		800	Topical	Delayed	Parent	Yes

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53yo female, dilated cardiomyopathy, HFrEF, elective ICD. 37 kg, 85/40 mmHg, 200 mg lidocaine for local anesthesia. Pain → 400 mg more (total, 16mg/kg). Shortly after, LOC, GCS 3. Epi, no effect. Anesthesiologist called to evaluate. 20% lipid emulsion 1.5 mL/kg bolus + infusion @ 0.25 mg/kg/min. Neuro-status improved to GCS 10, regained full consciousness.

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Systems Can Mitigate Risk of LAST

- ID high-risk patients
- Checklist: pre-block and during LAST
- Timeout: dose limit, risks

ABOVE ALL, USE COMMON SENSE!!!!



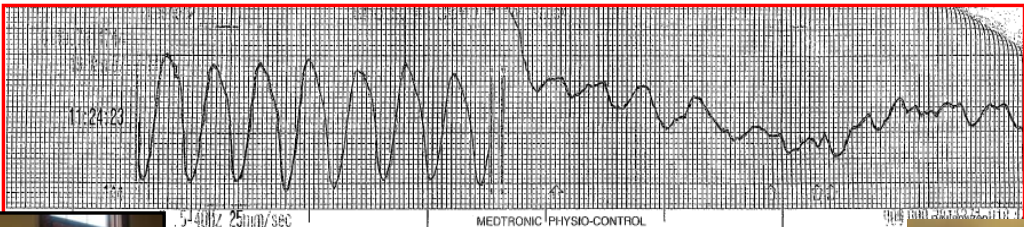
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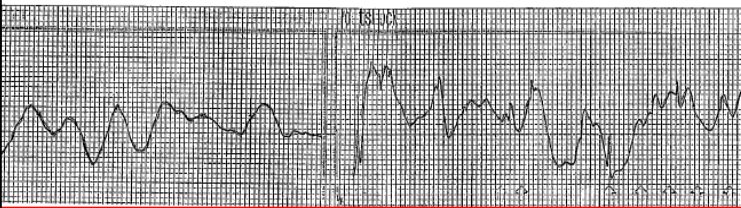
Consider Systems Refinements that Could Reduce Risk of LAST In Your Institution or Facility

- Who does the blocks?
- Who documents (time, aspiration, dosing)
- Who supervises blocks?
- Is monitoring sufficient?
- USGRA...but this isn't a panacea
- Who monitors patients after the block
- Are there contraindications to PNB?
- Timeouts....including weight, med hx
- Is there a weight-based dosing limit?
- Standard formulation of LA?

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Bupropion/Lamotrigine Suicide Attempt






VT, VF, TdP, PEA

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More Than 90 Minutes CPR

Time	Vital Signs	EKG Rhythm	Interventions Shock, Drugs, IV, Intubation Procedures	Response/ Comments	CPR: (yes/no)
1221	94	Initial Rhythm: <i>POA</i>	<i>epi. + Epi gtt</i>		<i>y</i>
1222	<i>Pulse</i>	<i>✓ faint</i>	<i>CPR continued</i>		<i>y</i>
1224	<i>154/50</i>	<i>✓</i>	<i>accu 385</i>		<i>y</i>
1225	75		<i>Epi ABG</i>		<i>y</i>
1229			<i>Epi</i>		<i>y</i>
1231	<i>162 ccPR</i>		<i>CaCl</i>		<i>y</i>
1234	<i>84 84</i>		<i>Epi</i>		<i>y</i>
1235	<i>Pulse</i>	<i>✓</i>	<i>φ Pulse CPR</i>		<i>y</i>
1236	<i>124/70</i>		<i>terro gtt</i>		<i>y</i>
1238	<i>Pulse</i>	<i>✓</i>			<i>y</i>
1239	78	<i>dg</i>	<i>Epi</i>		<i>y</i>
1243	<i>101/114</i>	<i>✓</i>	<i>Epi: 100ml lipiod push</i>		<i>y</i>
1246	<i>82 25/100</i>		<i>Vent PR 20 100 100</i>		<i>y</i>
1248			<i>Dose wide</i>		<i>y</i>

Epi: 18mg
 Shocks: 11 X
 Ca 1g
 Mg 1g
 HCO₃ 150meq
 Amio 300mg
 Max: Dop, NE, E

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Contents lists available at ScienceDirect
Resuscitation
journal homepage: www.elsevier.com/locate/resuscitation

Case reports
Intravenous fat emulsion therapy for intentional sustained-release verapamil overdose^a
Amy C. Young^{a,b,*}, Larissa I. Velez^c, Kurt C. Kleinschmidt^d
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ARTICLE IN PRESS
TOXICOLOGY/CASE REPORT
Use of Lipid Emulsion in the Resuscitation of a Patient With Prolonged Cardiovascular Collapse After Overdose of Bupropion and Lamotrigine
Archie J. Sirianni, MD
From the Department of Anesthesiology (Sirianni) and Division of Cardiology (Goodkin), Riddle
Anesthesiology, 2020, 64, pages 191–194
doi:10.1016/j.ana.2018.07.044

CASE REPORT
Early treatment of a quetiapine and sertraline overdose with Intralipid^a
and N. Sable^a
^a Department of Anesthesia, Working Hospital,
Abstract
We report here a case that involves the use of intravenous lipid emulsion as an antidote for a drug overdose involving a 20-month-old girl who had ingested a potentially lethal amount of the tricyclic antidepressant (TCA) desipramine. The patient's condition continued to deteriorate despite implementation of standard pediatric treatment recommendations for TCA toxicity. Administration of intravenous lipid emulsion led to resolution of the patient's condition.

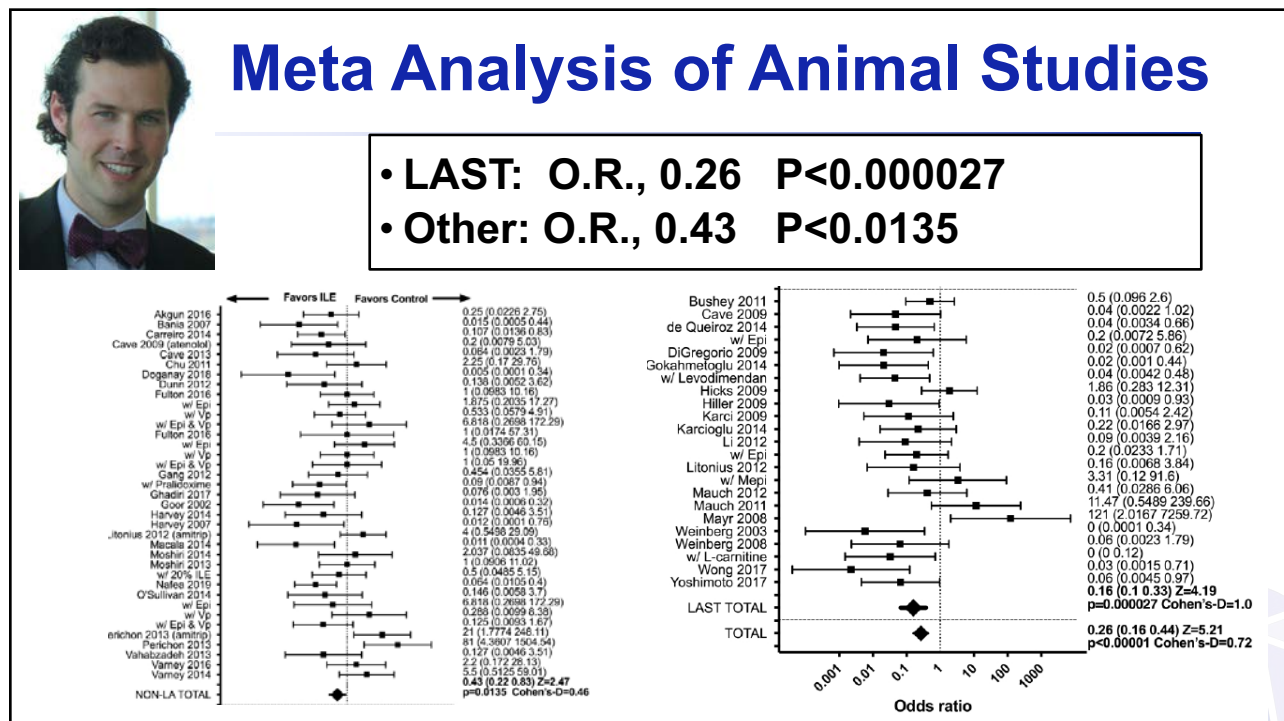
Resuscitation
journal homepage: www.elsevier.com/locate/resuscitation

Case report
Intravenous fat emulsion to reverse haemodynamic instability from intravenous amitriptyline overdose^a
Paul T. Engebretsen^{a,*}, Jonathan S. Davidow^{a,b,c}
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^b Department of Emergency Medicine, University of Alberta, Canada
^c University of Alberta, Royal Alexandra Hospital, Edmonton, Alberta, Canada

Tricyclic Antidepressant Overdose in a Toddler Treated With Intravenous Lipid Emulsion
abstract
We report here a case that involves the use of intravenous lipid emulsion as an antidote for a drug overdose involving a 20-month-old girl who had ingested a potentially lethal amount of the tricyclic antidepressant (TCA) desipramine. The patient's condition continued to deteriorate despite implementation of standard pediatric treatment recommendations for TCA toxicity. Administration of intravenous lipid emulsion led to resolution of the patient's condition.

Usefulness of Intravenous Lipid Emulsion for Cardiac Toxicity from Cocaine Overdose
Natasha Puri Arora, MD^a, William Allen Berk, MD^b, Cynthia Kurke Aaron, MD^{c,d}, and Kim Allan Williams, MD^{c,e}
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The graph, titled "Chart Window", plots Left Ventricular Pressure (LVP) in mmHg against time. The y-axis ranges from 0 to 100 mmHg, and the x-axis ranges from 700 to 800. The data is represented by a red line. The plot is divided into three distinct phases by two blue arrows pointing to the start of high-frequency oscillations at approximately 705 and 775. In the first phase (700-705), LVP is high and oscillatory, ranging from ~15 to ~95 mmHg. In the second phase (705-775), LVP is lower and more stable, ranging from ~20 to ~40 mmHg. In the third phase (775-800), LVP returns to high-frequency oscillations, ranging from ~15 to ~100 mmHg.

Red Tide
Brevetoxin:



The chemical structure of Brevetoxin is a complex polyether molecule. It features a long, zig-zagging carbon chain with multiple ether linkages (oxygen atoms) and several methyl groups (Me) attached. The structure is highly branched and includes a terminal aldehyde group (H₂C=O) and a hydroxyl group (HO). The overall structure is characteristic of a potent neurotoxin.



Perrault, Barron, Malinowski, Milton and Manire
Nature, Scientific Reports. (2021) 11:2416

...plasma brevetoxins declined faster compared to turtles that received only SSC; survival rate was 94% (17/18), which is significantly higher than standard supportive care (47%; 46/99). Nearly all symptoms were eliminated within 48 h, whereas using SSC, symptom elimination could take up to seven days.

A Career Path Is Not a Straight Line



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“Chance favors the prepared mind”

- Louis Pasteur, 1854

Patience
Luck



Look for the black swan
Keep asking, ‘Why’?

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It's All About the People!



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**Thank
you!**



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