A young stroke patient with awkward gait

Inter-hospital Rehab Meeting
TWEH
Dr. YUEN Ka Hong
15-1-2009

Case presentation

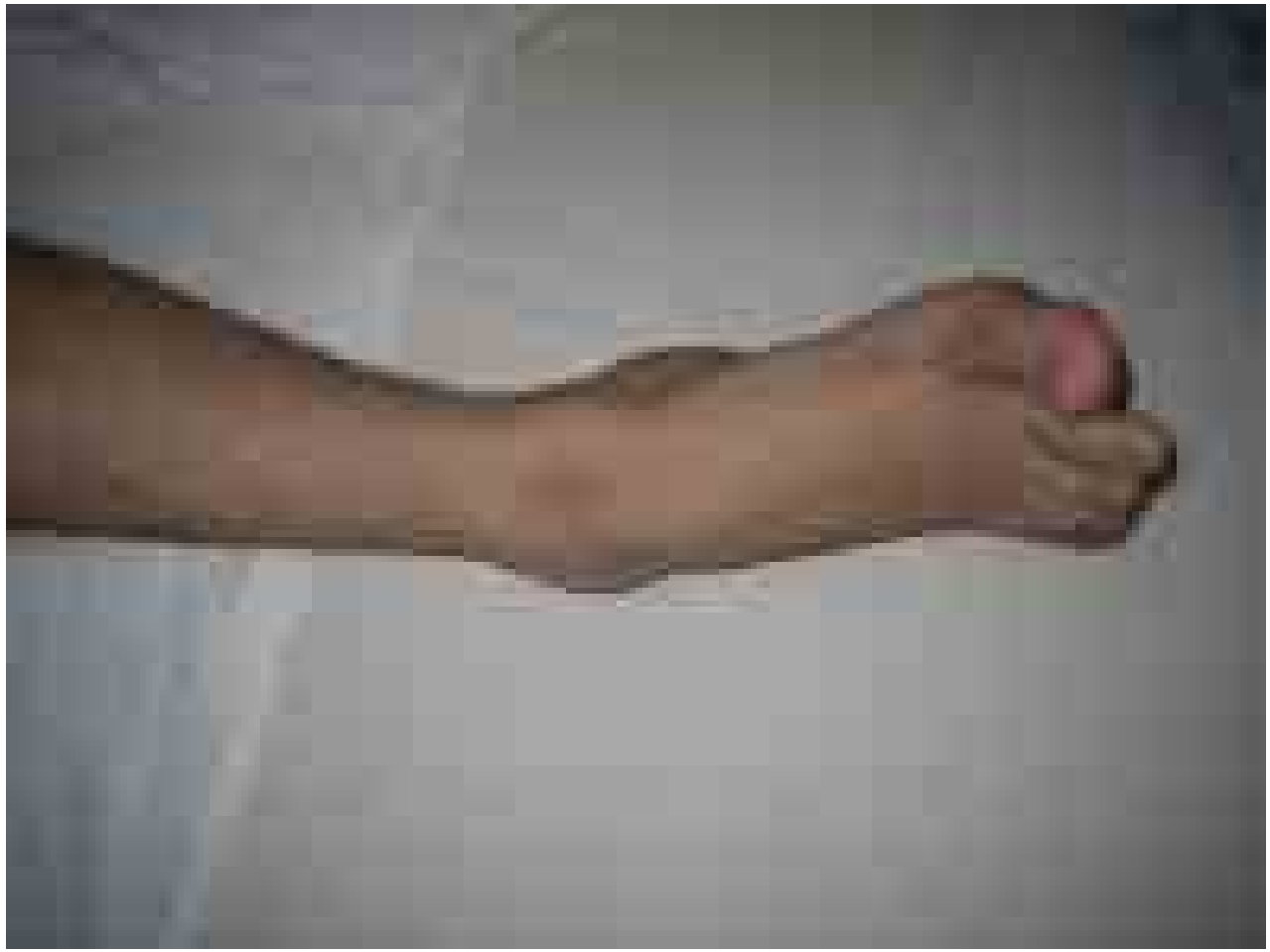
- KMW, M/43
- NDNS.
- PH: HT, defaulted treatment.
- Admitted for acute L ICH resulting in dense R hemi-paresis
- Initially admitted to CMC because he collapsed at work place (Kowloon side)
- Later referred to TWEH ambulatory centre after his acute hospital stay

Physical examination

- BP: 125/75 mmHg. P: 80 bpm.
- Good general GC. Afebrile.
- CVS, chest and abdominal exam: normal
- Cranial nerves: intact.
- No cerebellar sign.
- Could not walk by himself. Transfer: need 2 man-assistance.

LL examination

- Proximal power 4-/5
- R LL: in severe equinovarus deformity. MAS of ankle DF/PF was 4/4 (rigid)
- Walking: need 2-man assistance. Could hardly walk for few metres only.
- Walking aid: no use for him.
- His R LL mainly landed on lateral border of foot and R lateral malleous.



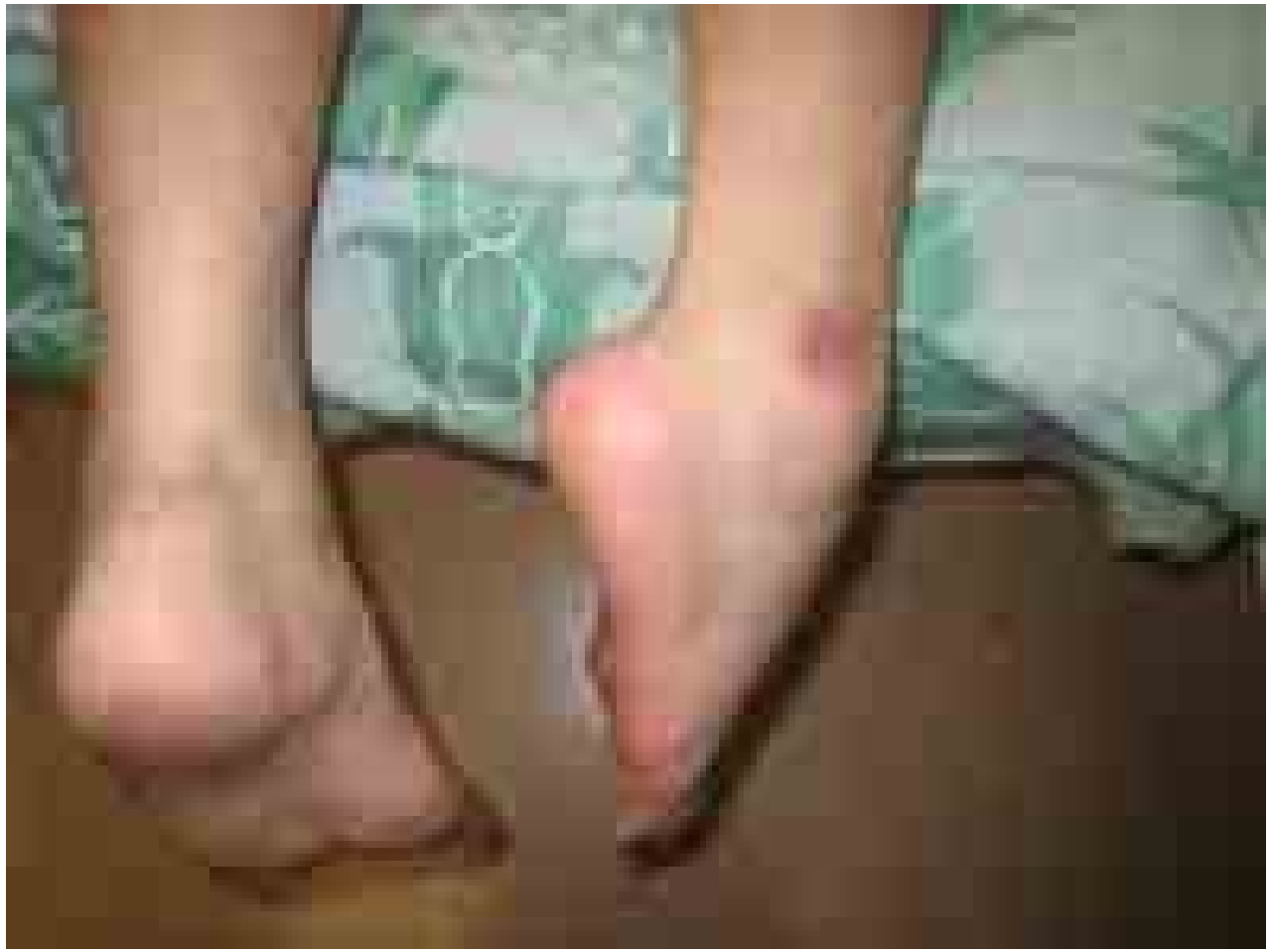
Clinical problems

- R Lower Limb Equinovarus deformity despite good proximal power.
- Impossible to walk independently because of this LL spasticity.

R LL equinovarus spasticity

- Possible involved muscle group: gastrocnemius, soleus, TA, TP.
- How do we know the involvement of TA?
- Use posterior tibial blockade at popliteal fossa

Equinovarus deformity



Posterior Tibial Nerve Blockade apparatus

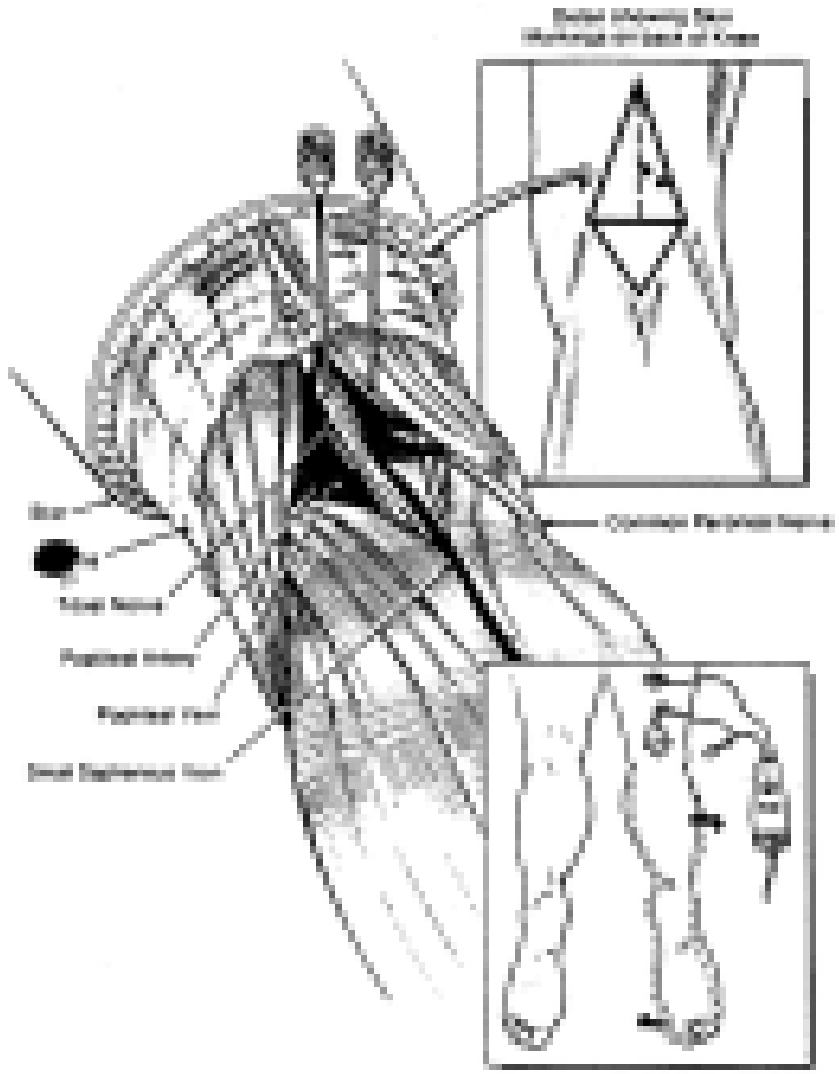
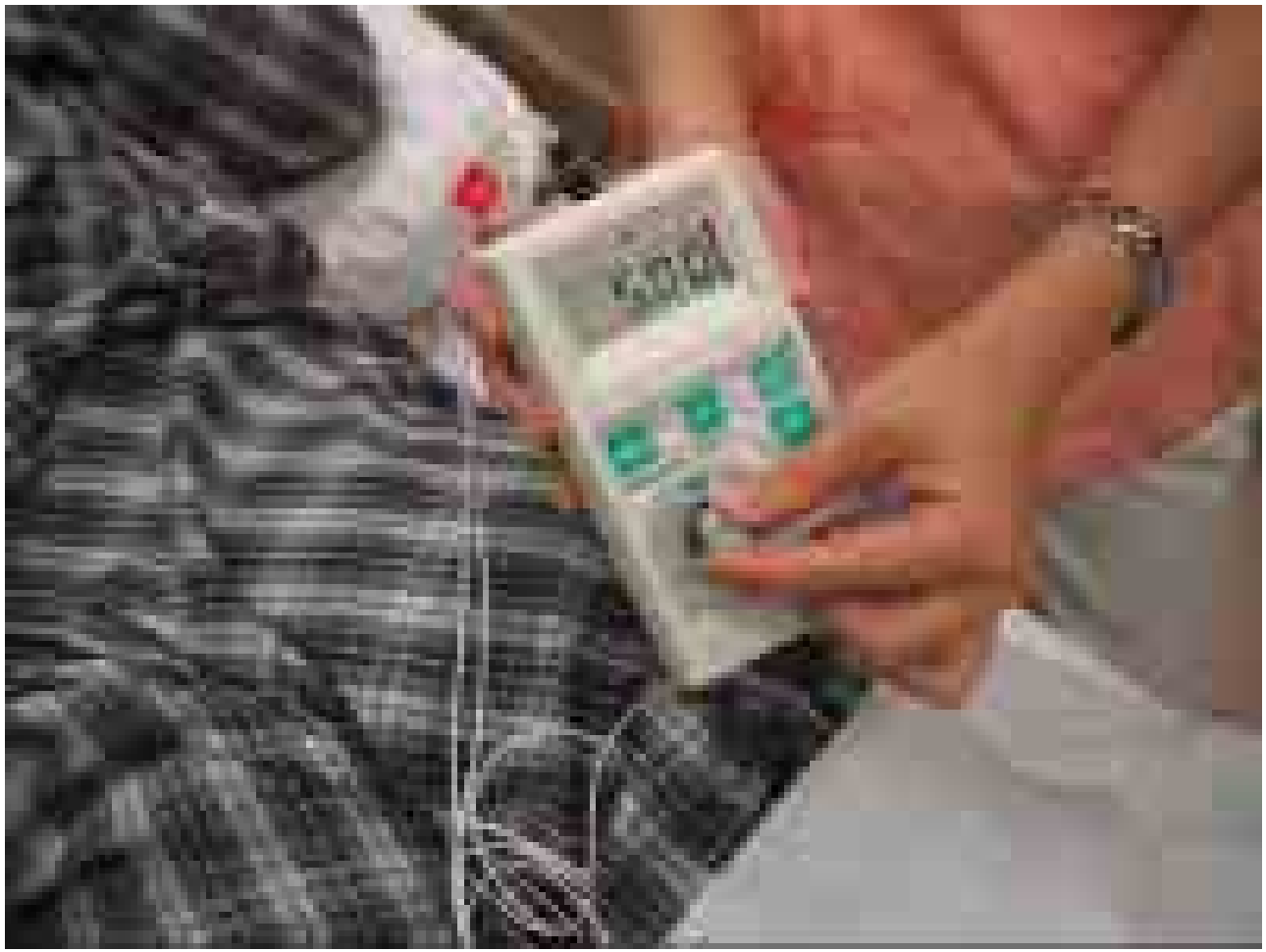


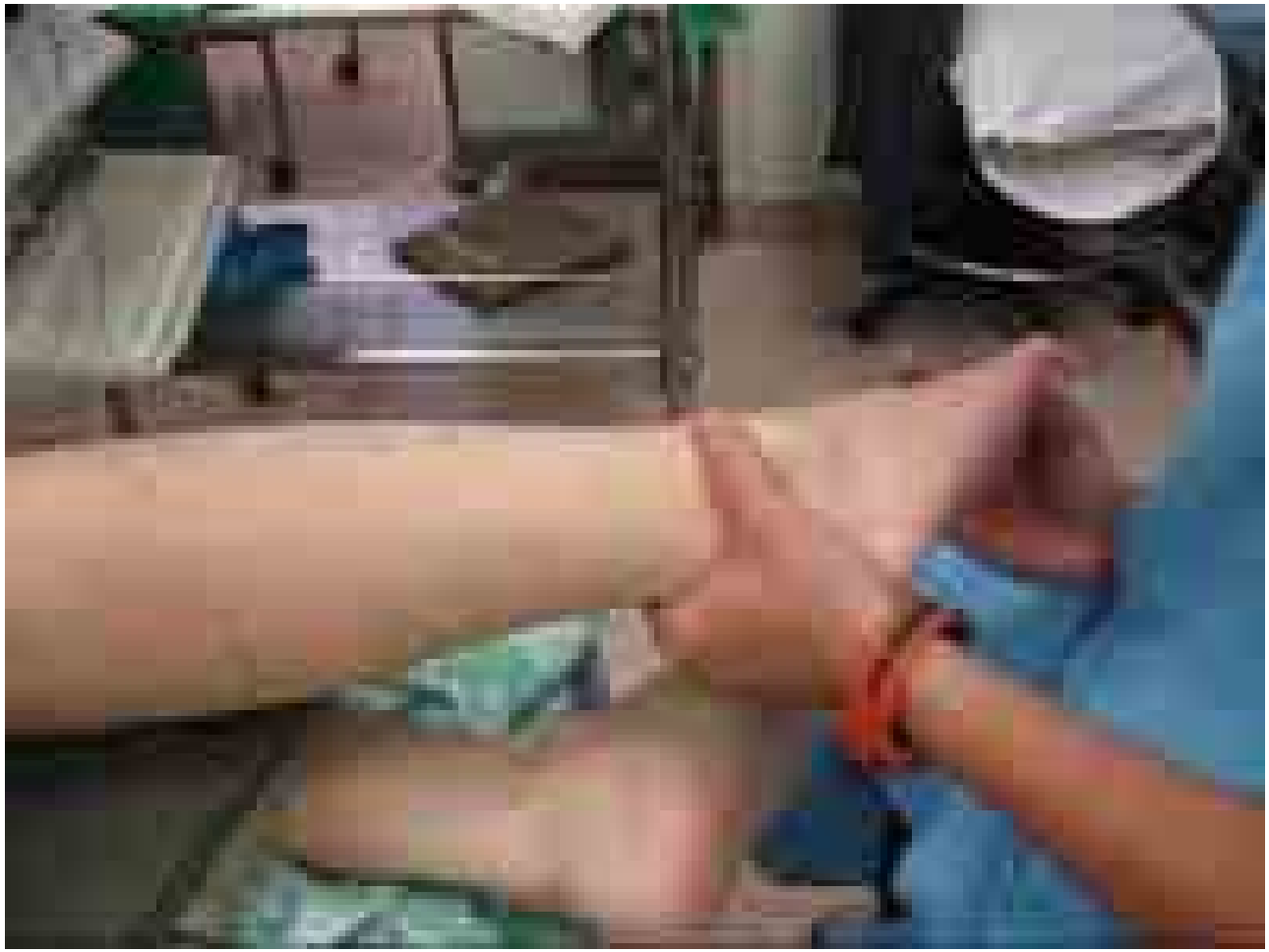
FIG. 23-17. Tibial and common peroneal nerve block at the knee. Approach for tibial and common peroneal nerve injection and neural blockade at the knee. Tibial and common peroneal (lateral popliteal) nerve. (Reprinted with permission from Enterkaugh PD. The lower extremity: somatic block. In: Cousins MJ, Enterkaugh PD, eds. *Neural blockade in clinical anesthesia and management of pain*, 2nd ed. Philadelphia: JB Lippincott, 1988; 433.)

Positioning of the needle tip to close proximity of PTN

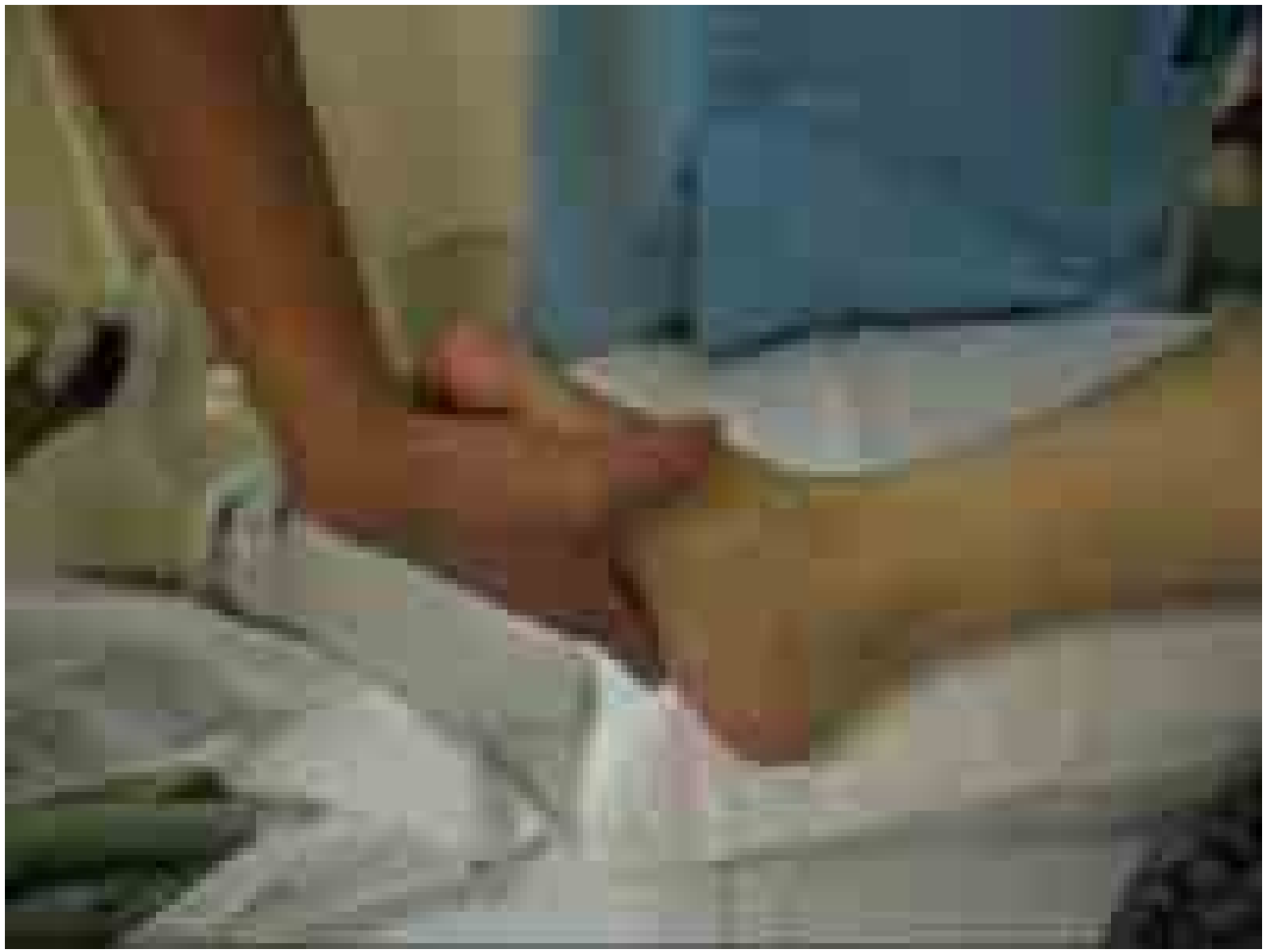


Injection of 2% lignocaine

5 minutes after PTN blockade



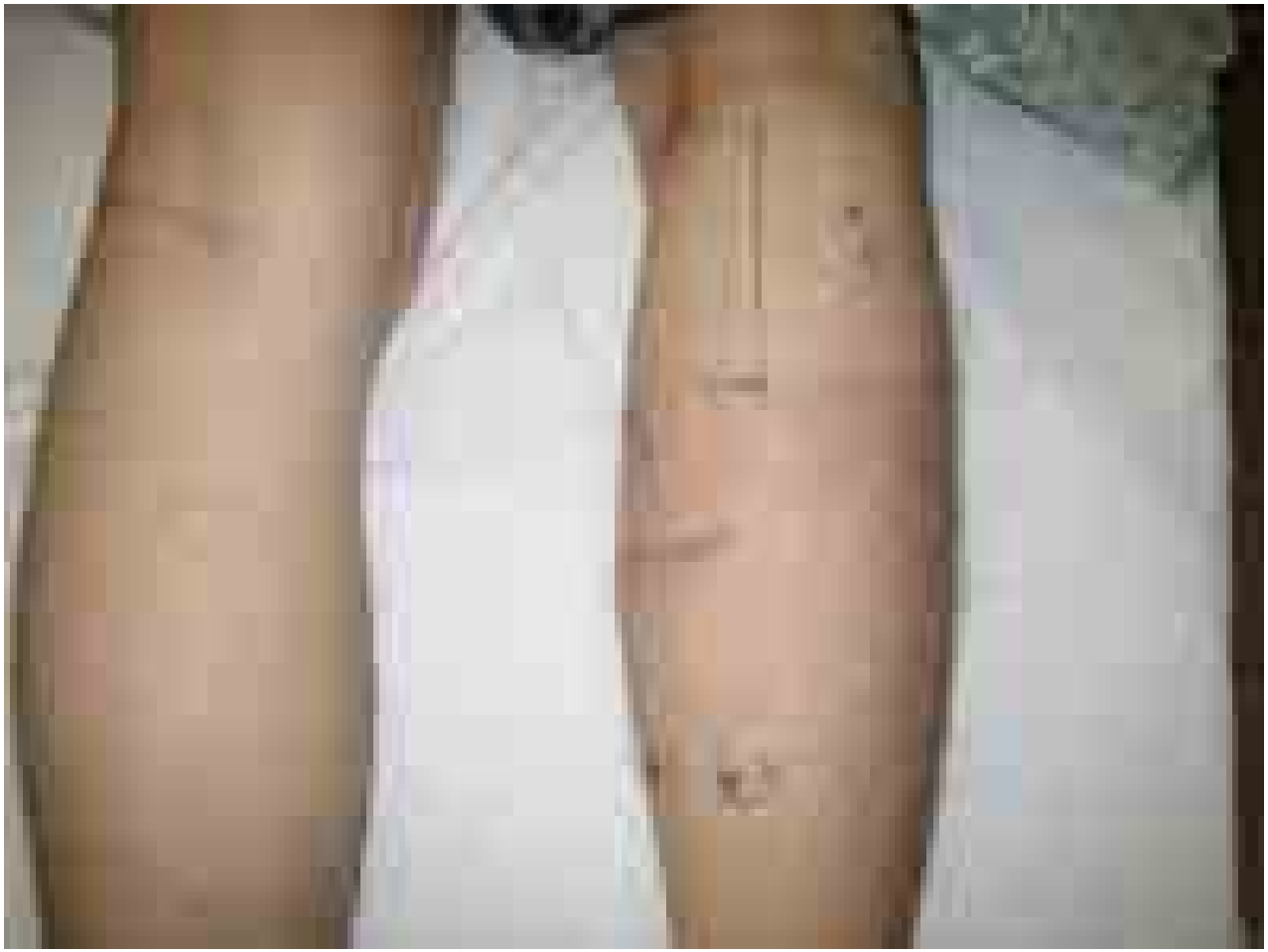
60 Minutes after Post. Tibial nerve blockade by lignocaine



Decision

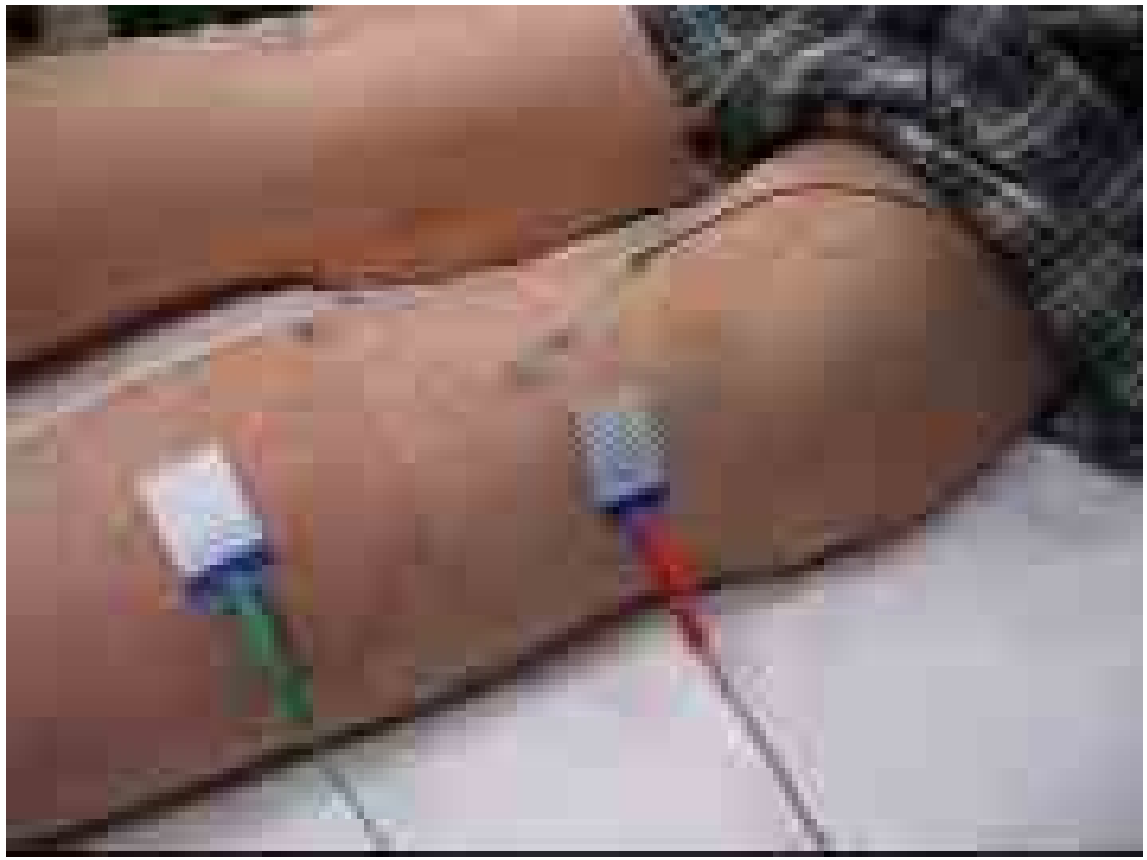
- PTN blockade did not result in too good spasticity relief.
- Therefore, involvement of TA was present.
- Injection of botulinum Toxin to TA would have clinical benefit.

Anatomical landmarkings

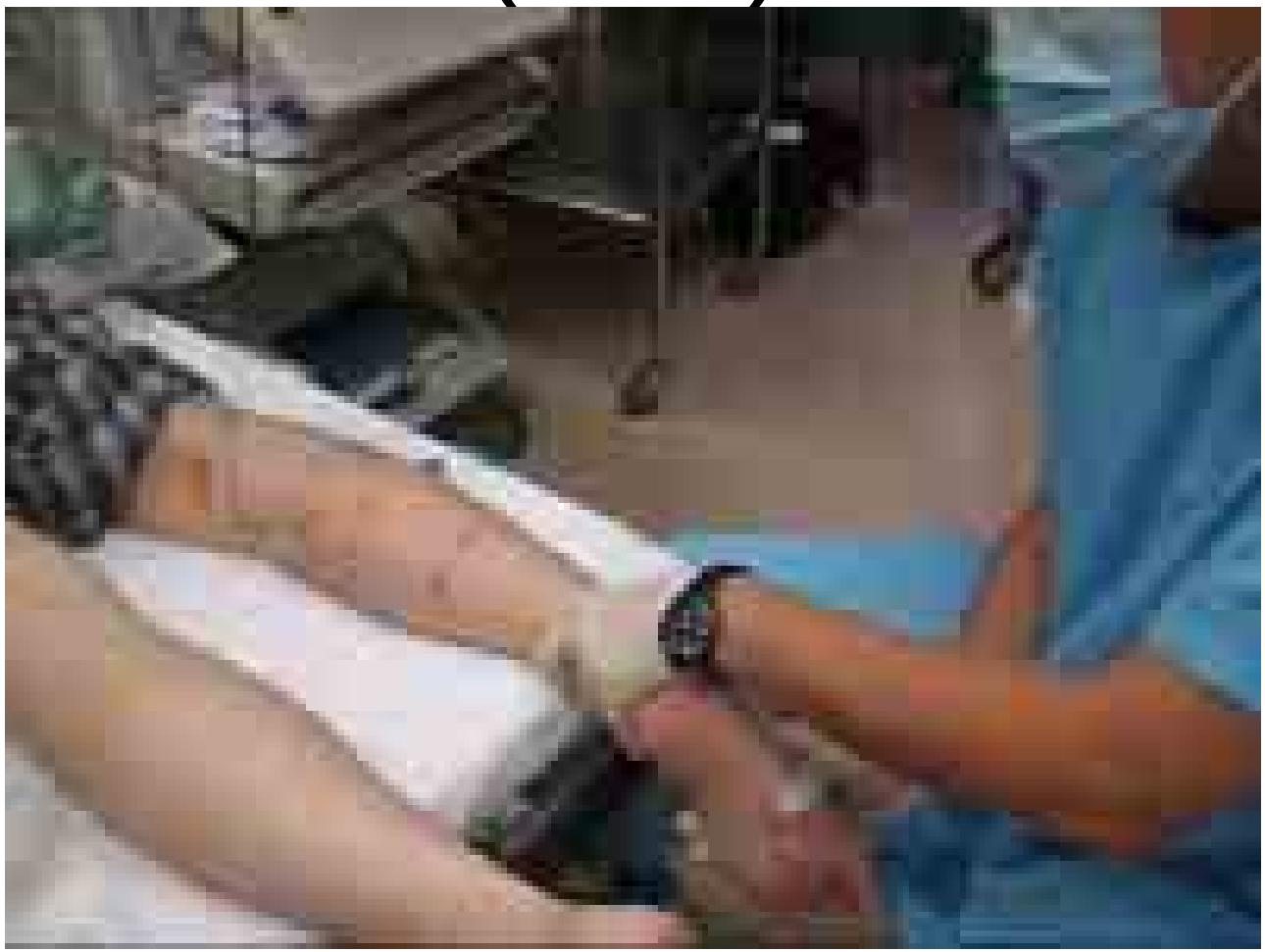


Dysport dilution

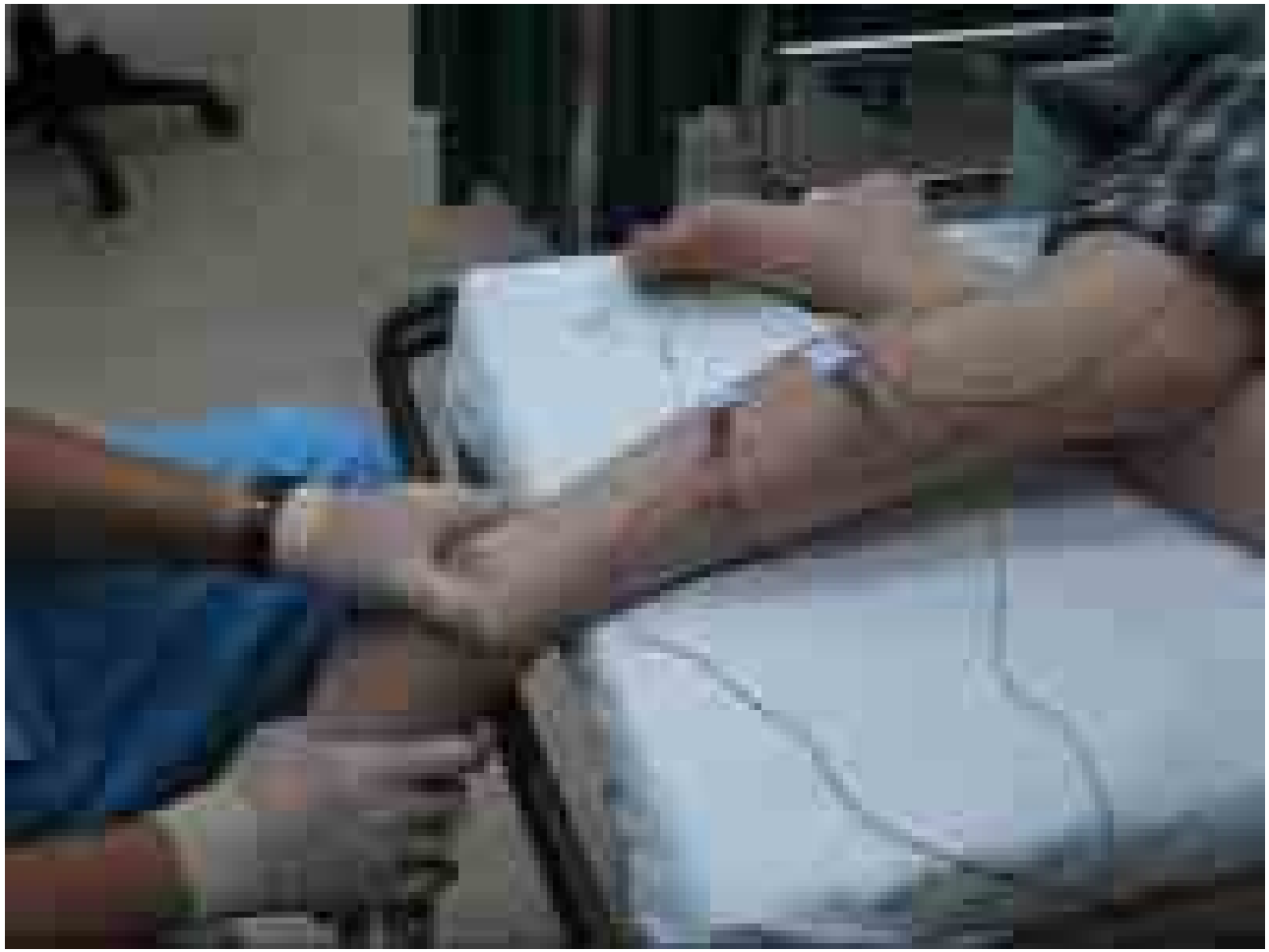
EMG activity of Gasctrocnemius (lat)



EMG activity Gastrocnemius (Med)

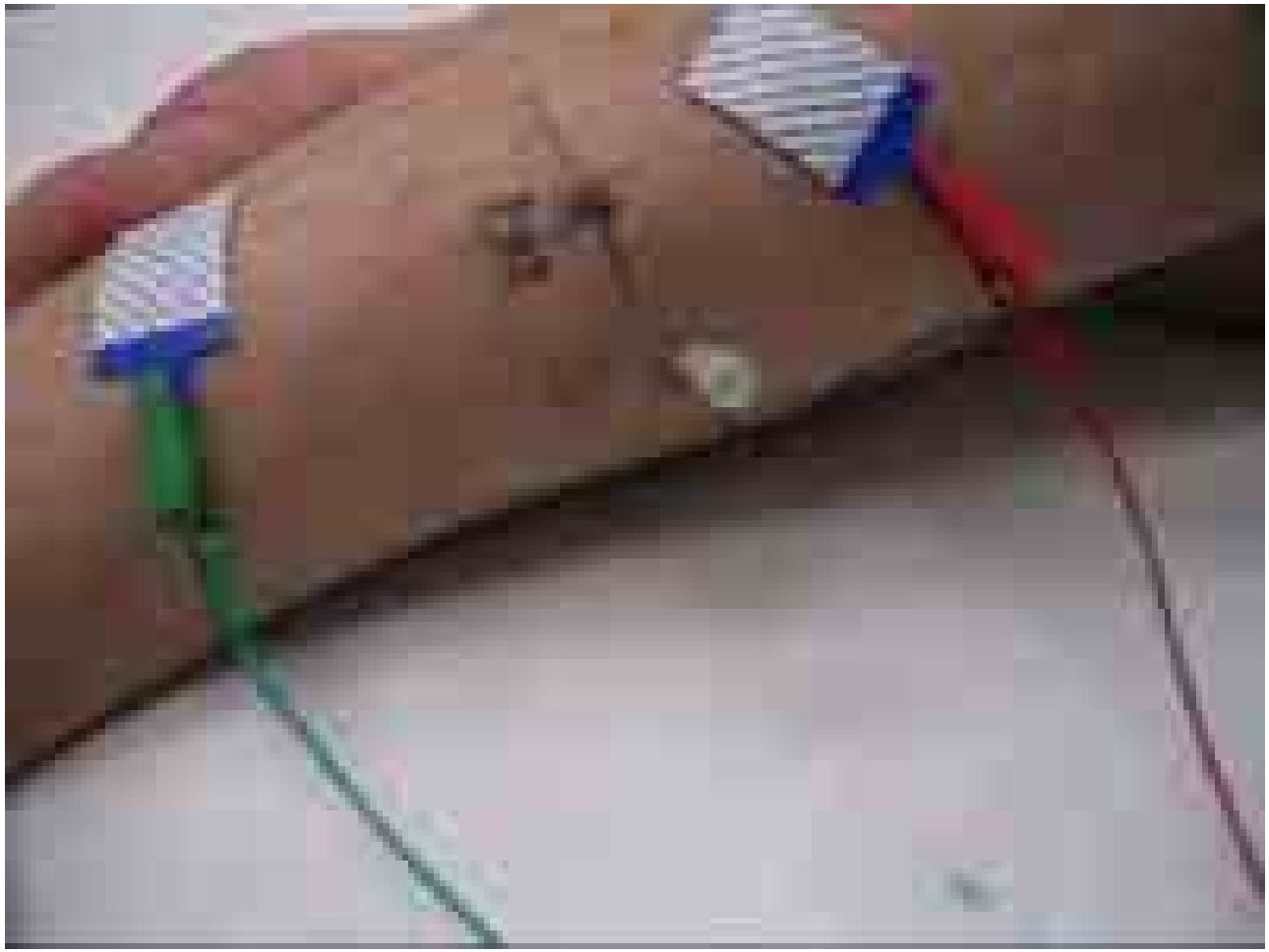


EMG activity of soleus

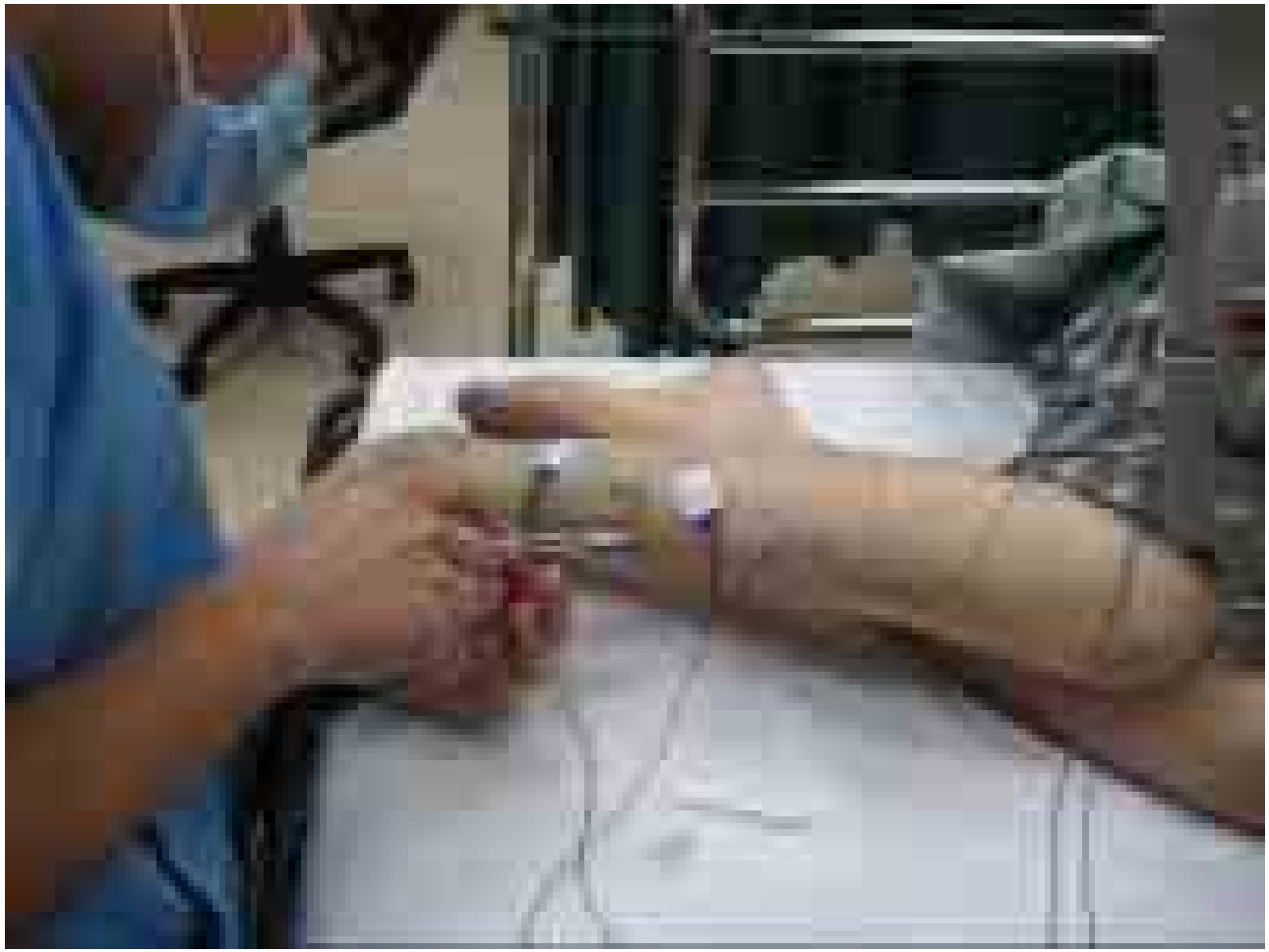


EMG activity of TP

EMG activity of TA



TP injection



Dosing of Dysport injection

- 500 units in 2.5 ml NS (1ml = 200 units)

Muscles	units	Volume (ml)	Number of sites
Soleus	200	1	2
Gastrocnemius	200	1	4
TP	300	1.5	2
TA	100	0.5	2
FDL	100	0.5	2
FHL	100	0.5	1
EHL	100	0.5	2

PBWSTT after dysport injection

3 weeks after Dysport injection

5 weeks after Dysport injection

Scope of discussion

- 1. Common LL spastic gait pattern
- 2. Botulinum toxin
- 3. Phenol blockade for proximal LL spasticity
- 4. EBM of Botulinum toxin in Rehabilitation

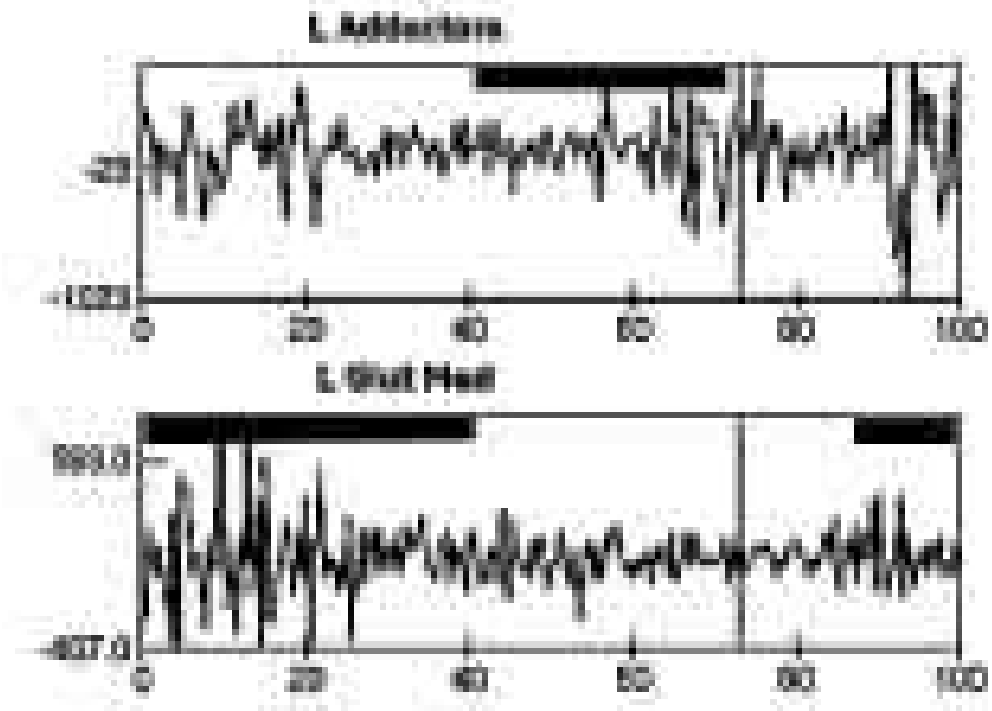
Common LL spastic gait pattern

PATTERNS OF MOTOR DYSFUNCTION ACROSS LOWER LIMB JOINTS AFFECTING GAIT

- Flexed hip
- Adducted (scissoring) thigh
- Stiff knee
- Flexed knee
- Equinovarus foot
- Hyperextended great toe

Use of Gait Analysis

Adducted (scissoring) thigh



Stance Swing

Adducted hips and narrow base of support

The gluteus medius has normal activation in stance phase and ***compensatory short lasted abnormal activation in swing phase***.

(Data are normalized where 0% indicates the initial contact and the beginning of the stance phase and 100% the end of the swing phase. The vertical line at about 75% of the gait cycle indicates the beginning of the swing phase.)

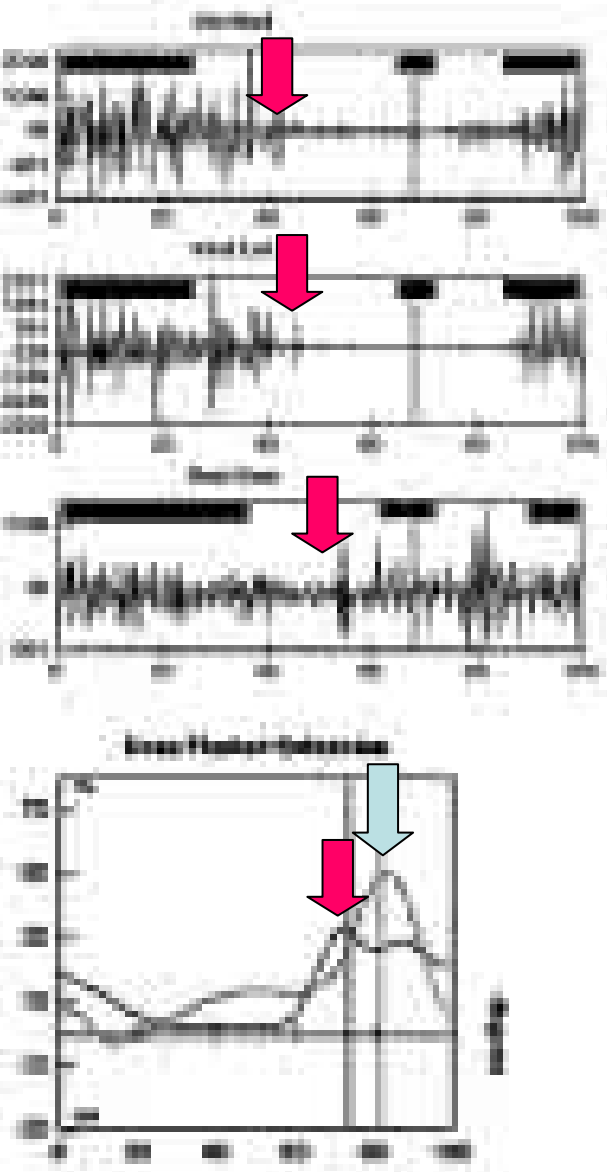
Problems of: Adducted (scissoring) thigh

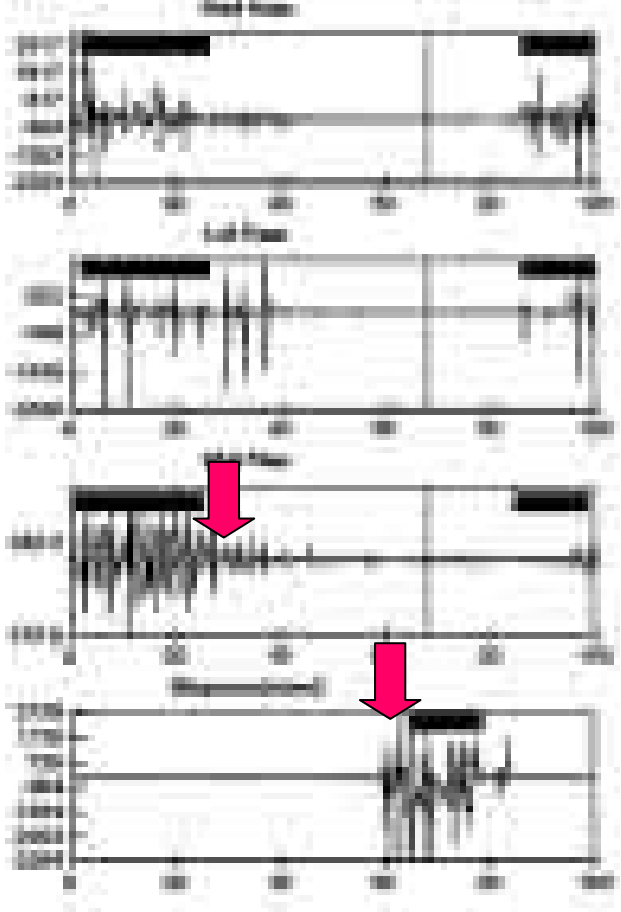
- Adduction of the hip during the late swing phase
- Narrow base of support in the stance phase of gait with balance impairment
- limb clearance and advancement interference
- Muscles that may contribute deforming forces include adductor longus, brevis, and magnus; gracilis and pectineus
- Weak muscles may include iliopsoas, gluteus medius, and sartorius.
- May use the hip adductors in swing phase to compensate for the weak hip flexors resulting in an adducted thigh

Use of motion analysis

- Dynamic poly-EMG recordings will demonstrate over-activation of the hip adductors, medial hamstrings, and pectineus
- It is essential to ascertain if the deformity is obligatory (i.e., the result of adductor spasticity) or compensatory (i.e., the result of weak hip flexors) since treatment will differ.
- A percutaneous temporary diagnostic obturator nerve block can be used to differentiate the role of hip adduction if the clinician is uncertain.

Stiff knee





Note the ***prolonged activation*** ***of other knee extensor muscles and the iliopsoas.***

(Data are normalized where 0% indicates the initial contact and the beginning of the stance phase and 100% the end of the swing phase. The vertical line at about 70% of the gait cycle indicates the beginning of the swing phase.)

The kinematic data demonstrate a ***limitation in the peek knee flexion to 30˚(top line)*** in comparison with a normal range for the left knee (bottom line).

Stiff knee problems

- lengthens the limb and poses clearance problems particularly during the pre-swing and swing phases of gait
- Toe drag in early swing may cause tripping and falling.
- The patient may attempt to compensate through limb circumduction, hip hiking, or contra-lateral early heel rise (vaulting).

EMG findings

- A reduction or delay is noted in the activation of iliopsoas along with excessive activation of the rectus femoris, vastus intermedius, vastus medialis, and vastus lateralis, gluteus maximus or hamstrings.
- If an ankle equinus deformity is also present, a reduction in joint power generation and PF moment may result in further reduction of swing phase knee flexion

Management plan of stiff knee

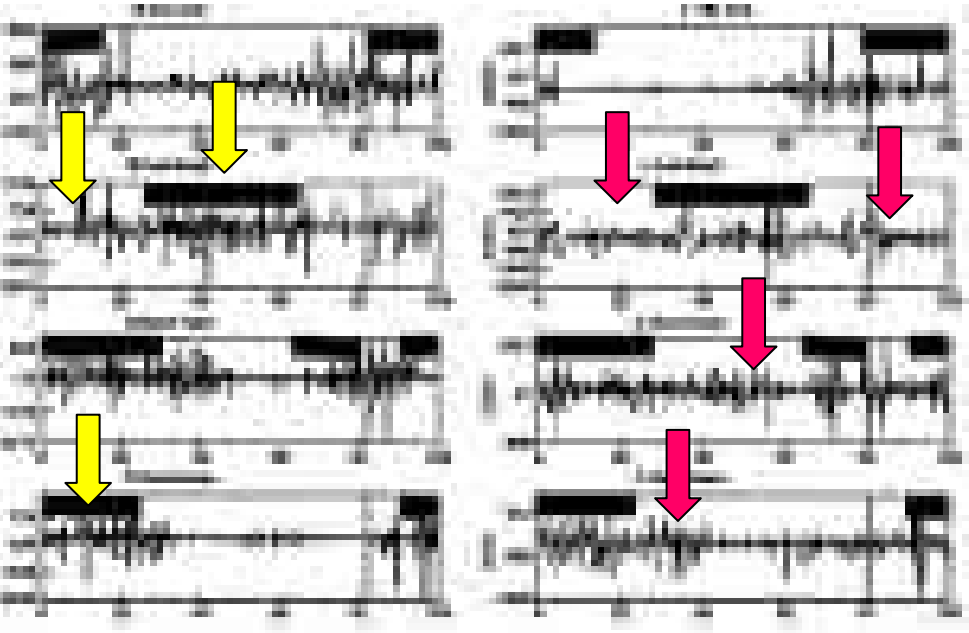
- Phenolization of the motor branch of the femoral nerve innervating the quadriceps mechanism or chemodenervation with BoTox to individual heads of the quadriceps or gluteus maximus as needed may be considered.
- Aggressive stretching of the rectus femoris and marching exercises and water walking also have beneficial effect.

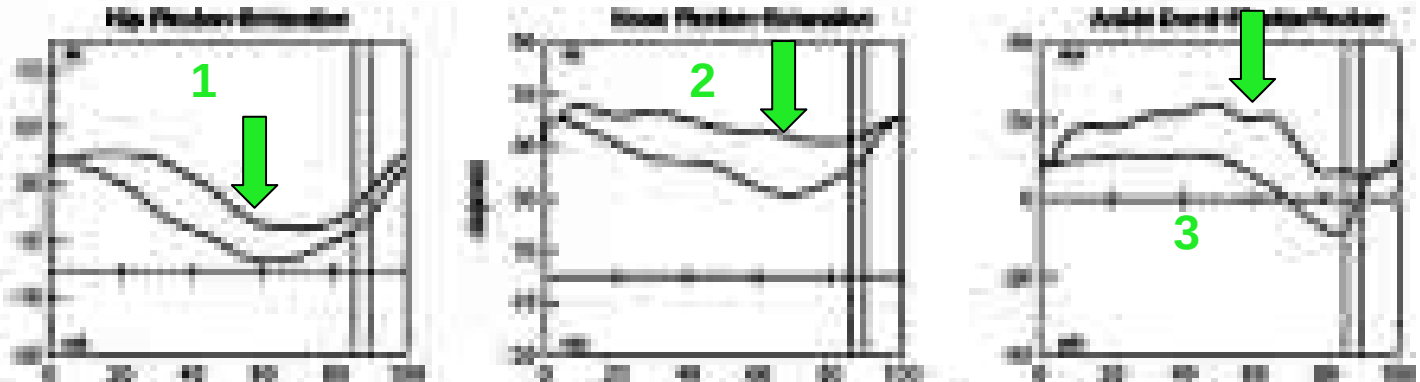
- (Reserve surgical interventions: a rectus to gracilis transfer, alone or in combination with selective lengthening of the quadriceps mechanism.)

*Flexed knee: a subject with flexed knee gait caused by **overactive L medial hamstring***

R: phasic activation for hamstrings and compensatory increase in muscle activity for gastrocnemius.

L: Over activation of rectus femoris and gastrocnemius





The kinematic data demonstrate ***sustained hip and knee flexion left*** [1] [2] ***(top line)*** more than right (bottom line) as well as ***excessive left ankle dorsiflexion in stance phase*** [3] (drop off gait).

Use of motion analysis

- Dynamic poly-EMG recordings obtained from medial and lateral hamstrings, quadriceps, gastrocnemius, and soleus should help clarify the contribution
- Frequently demonstrate **over-activation of the hamstrings**, medial more than lateral +/- excessive activity in the gastrocnemius
- Kinematic data demonstrate **limited knee extension** and, frequently, accompanying **compensatory hip flexion.**

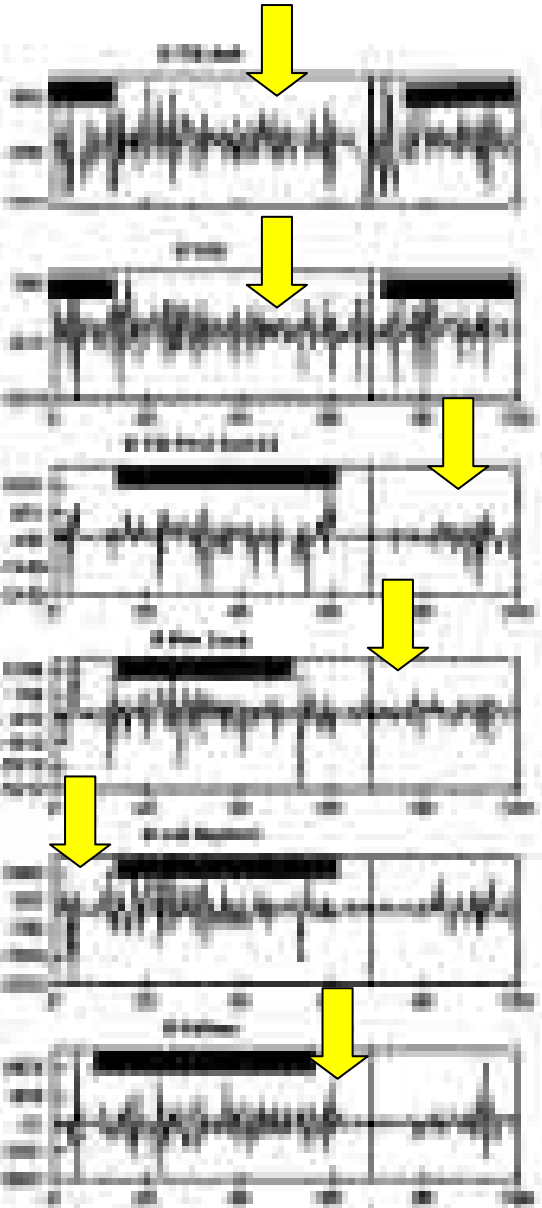
Intervention

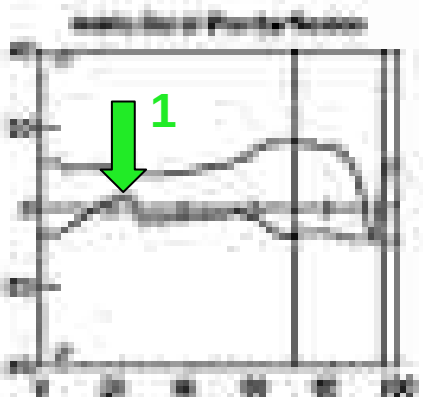
- Phenol neurolysis to the motor branches of the sciatic nerve, motor point blocks to the hamstrings, or chemodenervation with BoTox
- Weakened gastrocnemius and soleus group may lead to “drop off” pattern of gait in terminal stance: AFO can be used

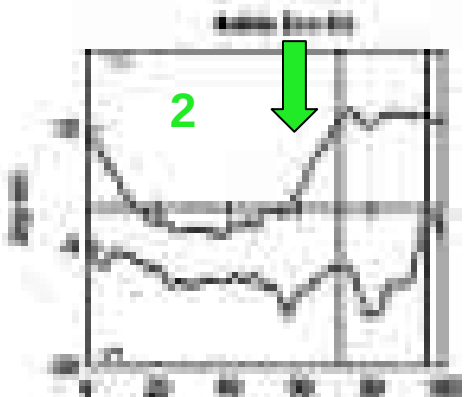
- (Reserve management Surgery: a transfer of the long toe flexors to the os calcis can be used as a technique to increase the plantarflexor muscle strength. In combination with surgical intervention such as hamstring distal lengthening or release followed by serial casting to address the knee flexion deformity)

Equinovarus Deformity

R ankle equinovarus deformity during the swing phase caused by ***overactive tibialis anterior, tibialis posterior, and gastrocnemius and soleus***







The kinematic data demonstrate a [1] ***limitation in the peak right ankle dorsiflexion to 5˚*** and ***significant*** [2] ***inversion (top line) in comparison with contralateral ankle range (bottom line).***

Equinovarus foot

- Muscles that potentially contribute : **TA, TP, long toe flexors, gastrocnemius, soleus, EHL** and reduced activity in the peroneus longus.
- Dynamic poly-EMG recordings: prolonged activation of the gastrocnemius and soleus complex and the long toe flexors
- Occasionally, the gastrocnemius and soleus may activate differentially and treatment interventions must take this into consideration.

TP Vs TA contribution in Equinovarus

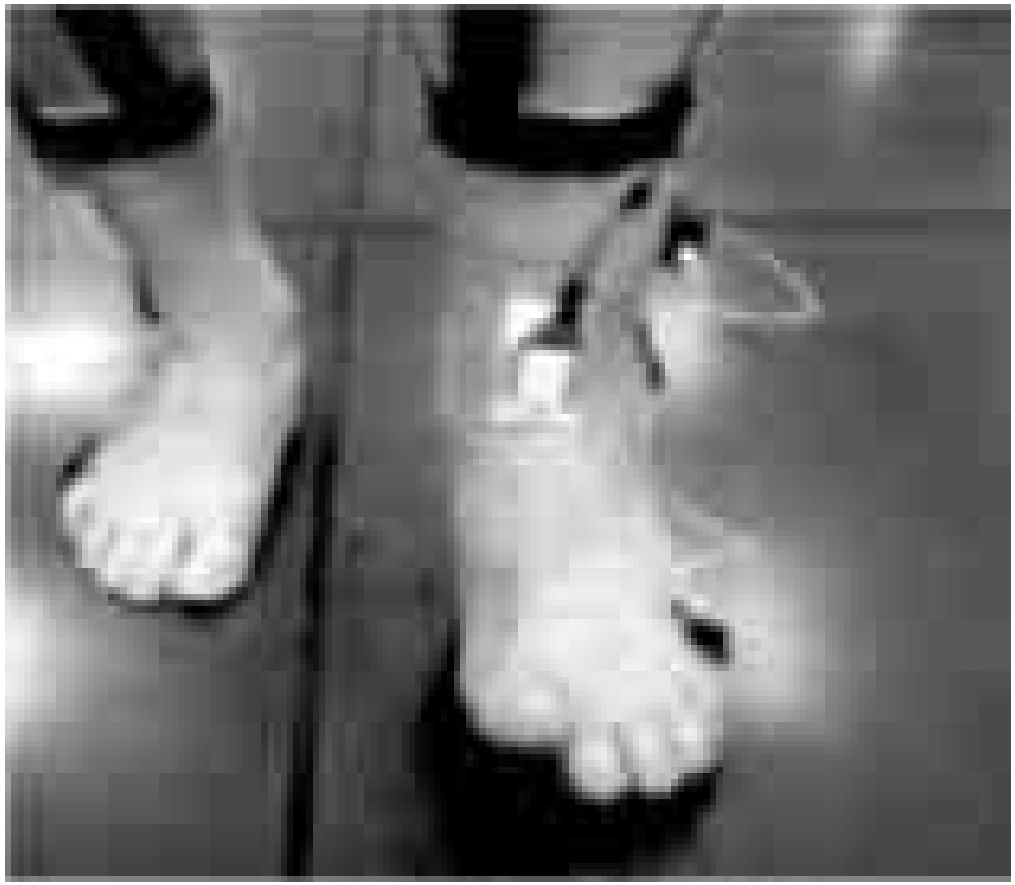
- Ankle inversion: overactivation of the TP +/- TA, plus gastrocnemius and soleus and +/- EHL
- If the TP and TA are both contributing to the varus deformity, a decision has to be made about which one of the 2 muscles is the most problematic
- A diagnostic posterior tibial nerve block with Lidocaine may help elucidate this question

Intervention

- The treatment of choice may be injection of BoTox into the TP, gastrocnemius, soleus, and long toe flexors.
- On occasions a very limited injection in to the TA may be indicated but caution should be exerted to avoid over-weakening of this primary ankle dorsiflexor.

- Reserve treatment of Surgery: tendon Achilles lengthening, toe flexor release and lengthening or transfer of TA +/- TP

Hyperextended great toe



Hyperextension of the left hallux during ambulation: The patient has surface electrodes recording from various muscles and CODA® active optoelectronic markers for 3D movement analysis

Clinical problems

- The great toe's in extension throughout most of the gait cycle.
- Lesser toe flexion is also noted
- During gait, toe extension in early and mid stance complicates the weight bearing function of the foot
- The patient will shorten stance time of the affected limb interfering with push-off and forward propulsion in terminal stance and pre-swing.
- During swing phase, there may be sustained hallux extension.

Motion analysis use

- Gait analysis and dynamic poly-EMG can elucidate the contribution of overactive gastrocsoleus group or under-active TA to this deformity as the EHL may be overactive in an effort to compensate for lack of DF in swing phase.

Intervention

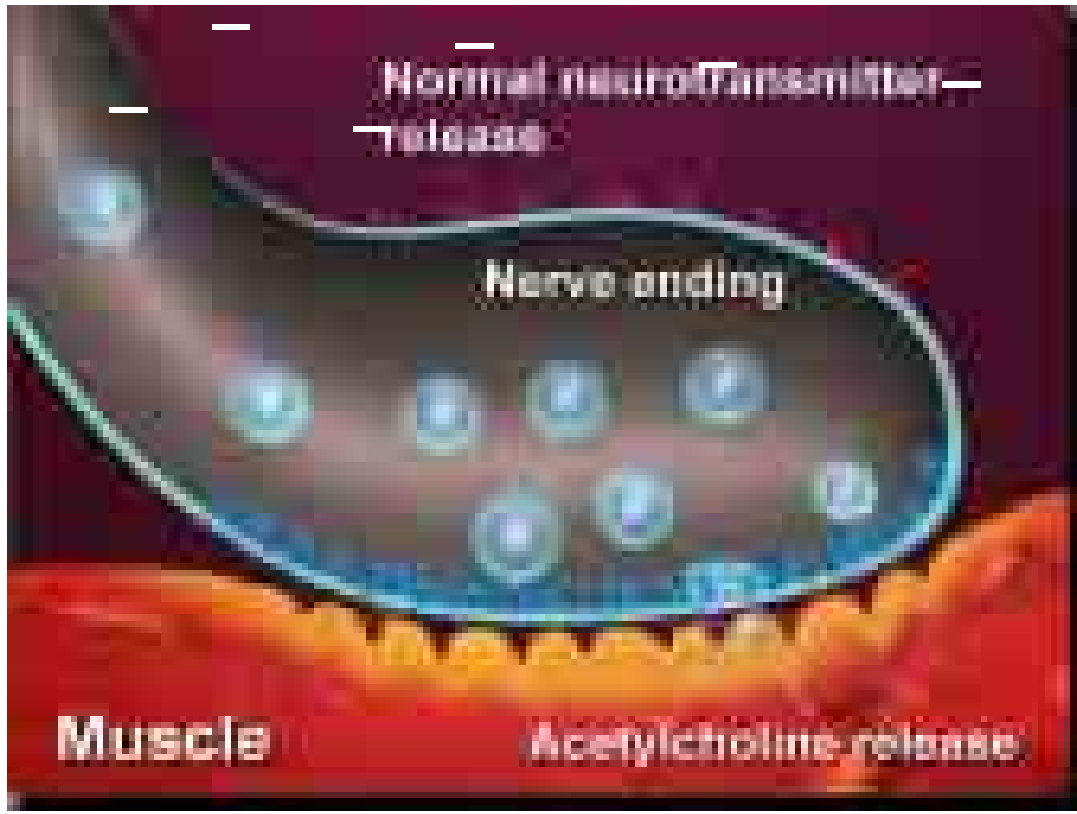
- A motor point block of the EHL with phenol or chemodenervation with BoTox can easily be achieved.
- Stretching of the EHL into flexion and strengthening of the TA should follow

- (Reserve surgical treatment: A percutaneous surgical lengthening of the EHL may be achieved for long-term relief of the deformity.)

Botulinum toxin

Normal Neurotransmitter Release

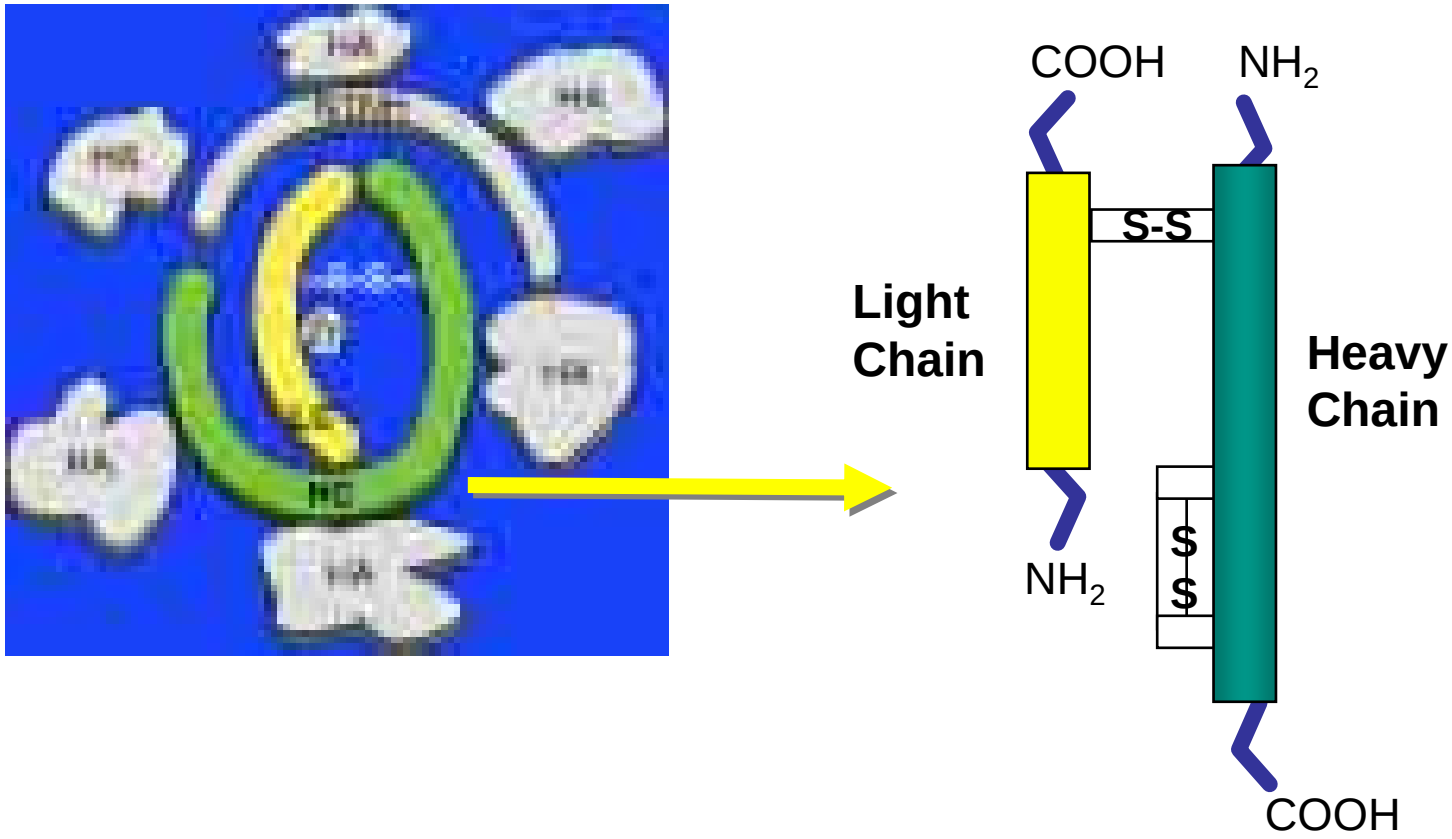
- At a normal neuromuscular junction, acetylcholine is released from the nerve ending
- Acetylcholine release causes the muscle to contract



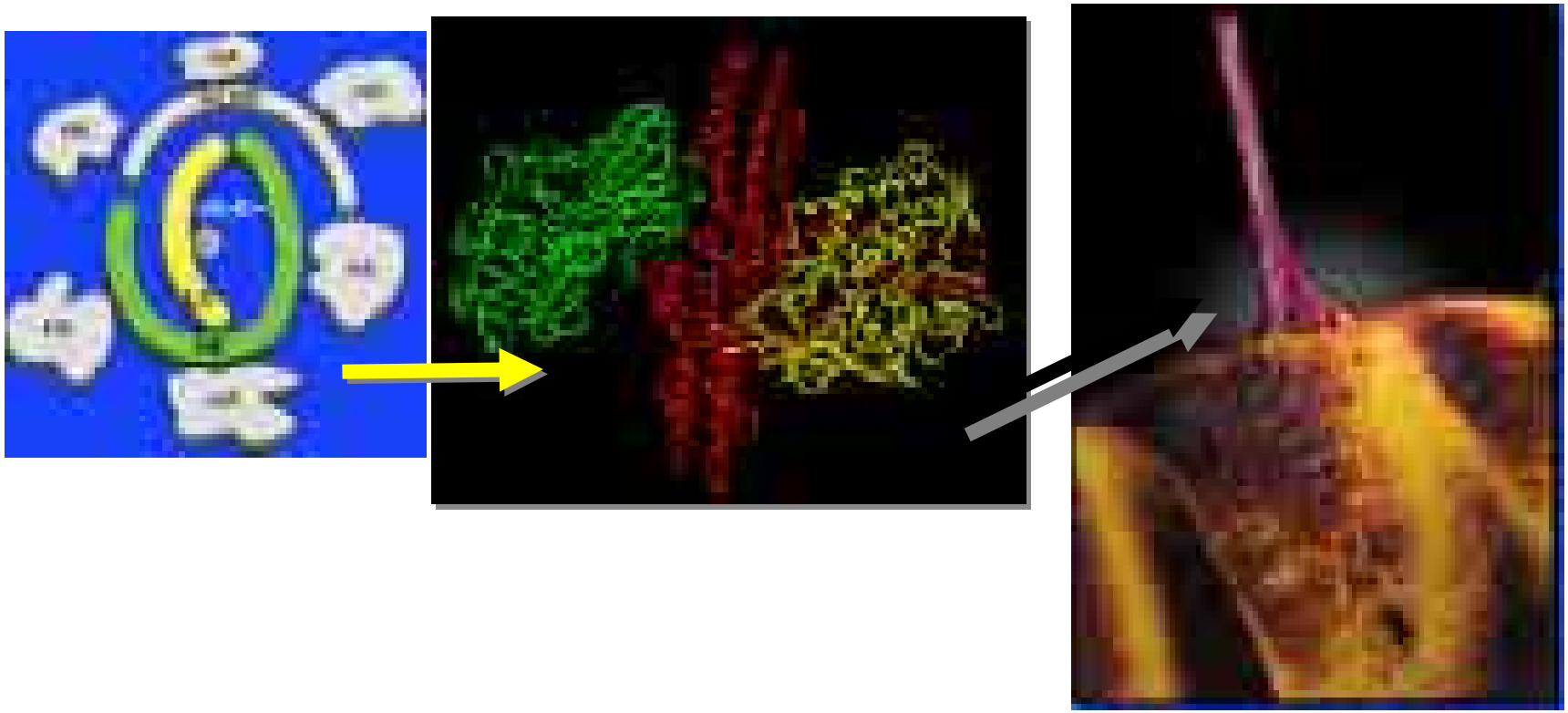
Pharmacology of Botulinum Toxins:

All Are Not The Same

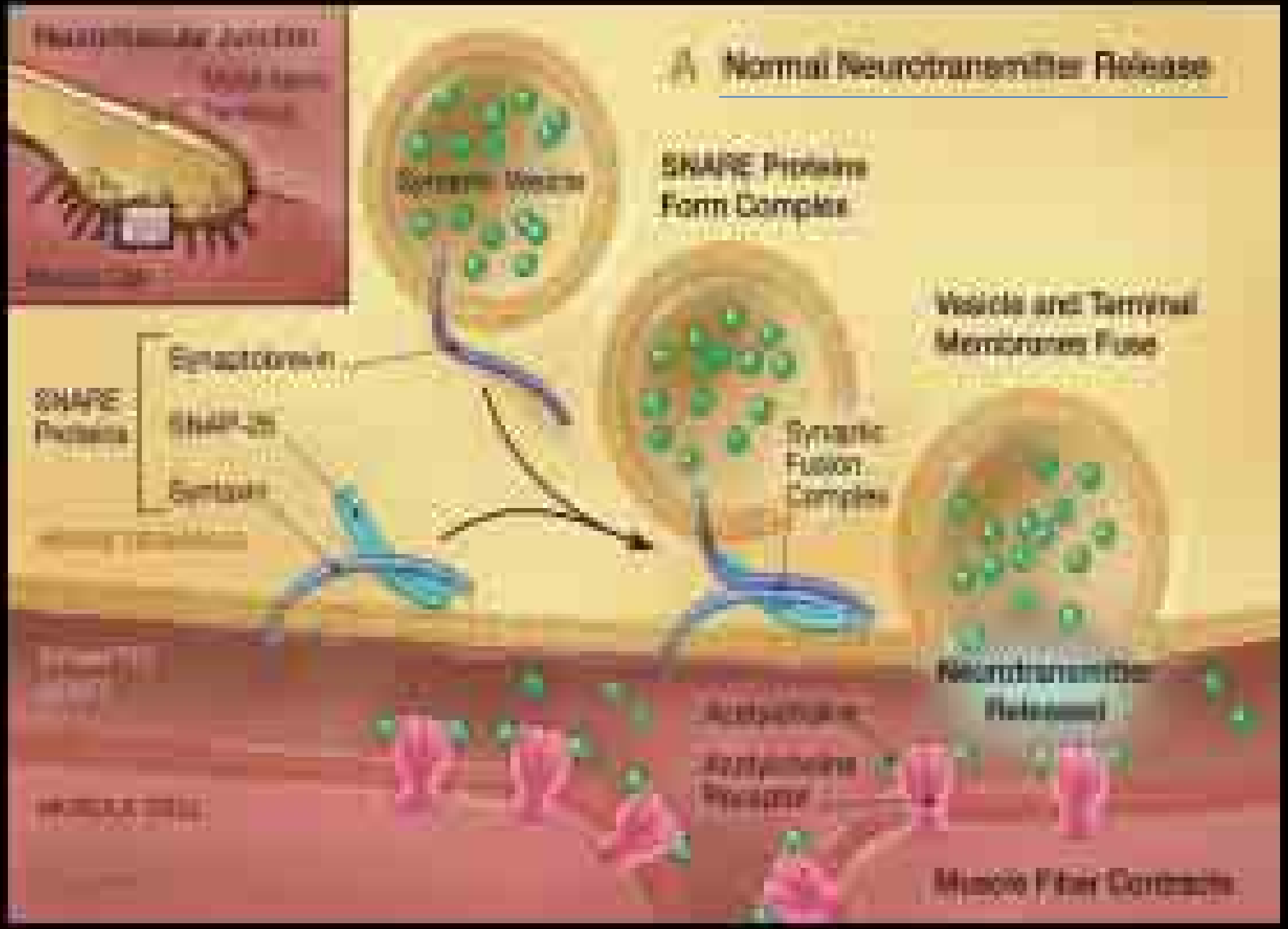
Botulinum Toxin Complex Injected and Neurotoxin Exerts Action

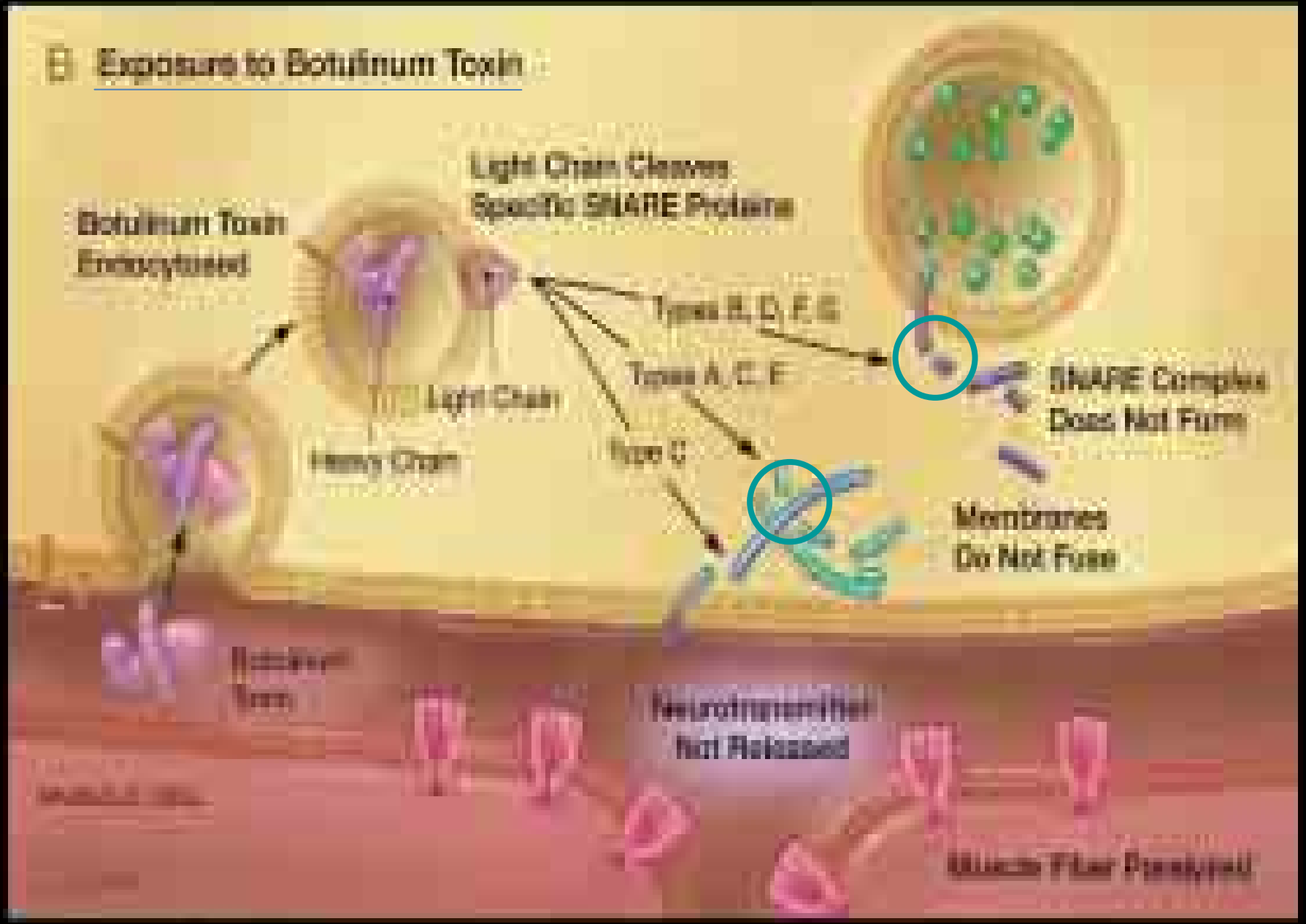


Botulinum Toxin Type A Has High Affinity For The Neuromuscular Junction

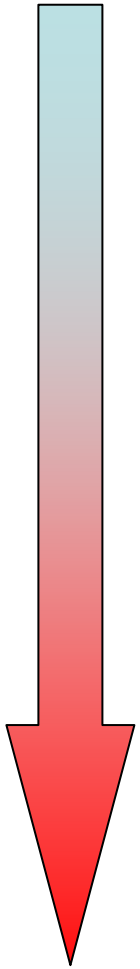


Local, Temporary Muscle Relaxation


A Normal Neurotransmitter Release
SNARE Proteins Form Complex
Synaptic Vesicle
Vesicle and Terminal Membranes Fuse
SNARE Proteins
Synaptobrevin
SNAP-25
Syntaxin
Synaptic Fusion Complex
Neurotransmitter Released
Acetylcholine Receptor
Muscle Fiber Contracts


Exposure to Botulinum Toxin
Botulinum Toxin Endocytosed
Light Chain Cleaves Specific SNARE Proteins
Types B, D, F, G
Types A, C, E
Type C
Light Chain
Heavy Chain
SNARE Complex Does Not Form
Membranes Do Not Fuse
Neurotransmitter Not Released
Muscle Fiber Paralyzed

BOTOX® Mechanism



- Muscle
  - Alpha & gamma motor neuron inhibition
  - Ia afferent reduction
- Glands
  - Parasympathetic nerve-induced secretion inhibition
- Nociceptors/Pain pathway
  - Muscle/Skin
    - C and A delta fibers (group III and IV)

Possible patho-physiology of spasticity

I. Increased motoneuronal excitability

- A. Increased excitatory synaptic input
  - 1. segmental afferents
  - 2. regional excitatory interneurons
  - 3. descending pathways
- B. Decreased inhibitory synaptic input
  - 1. Renshaw cell recurrent inhibition
  - 2. Ia inhibitory interneurons
  - 3. Ib afferent fibres
- C. ▲ intrinsic electrical properties of neurons

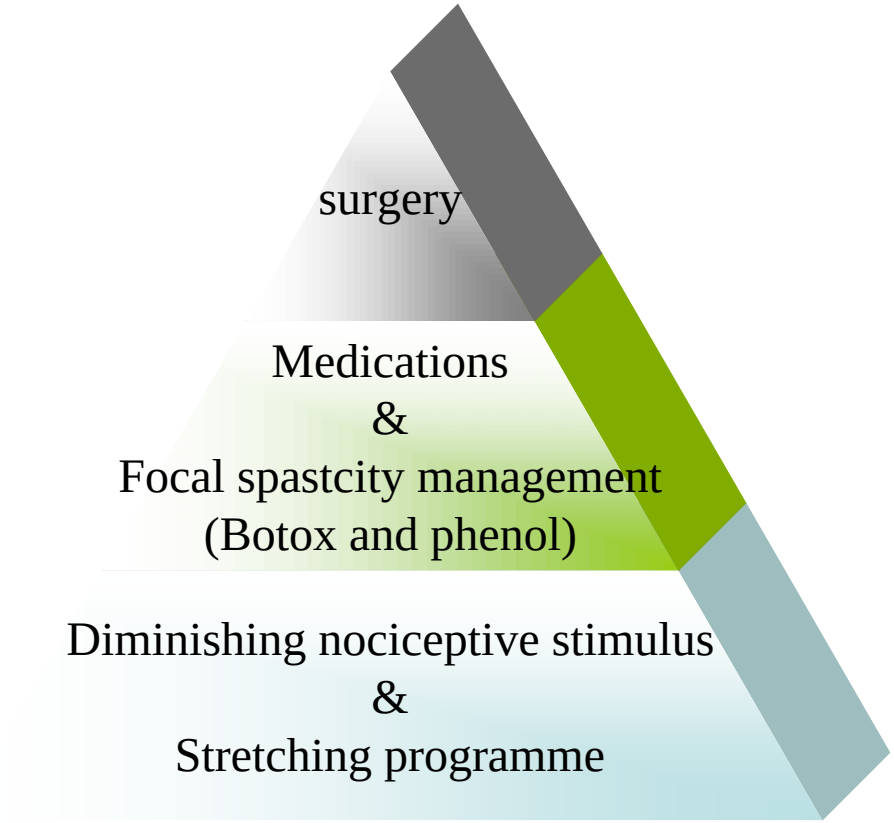
II. Increased stretch-evoked synaptic excitation

- A. γ efferent hyperactivity
- B. Excitatory interneurons more sensitive to muscle afferent: collateral sprouting, denervation hypersensitivity & $\downarrow$ presynaptic inhibition

When should interventions be given?

- Under the following circumstances, in which spasticity causes:
  1. pain
  2. decreased function
  3. causing contracture
  4. hygienic problems
  5. cosmetic problems

General approach to spasticity



Pharmacological treatments of spasticity

Oral	Baclofen Diazepam Dantrolene Clonidine Tizanidine
Intrathecal	Baclofen pump
Chemical neurolysis	Phenol Alcohol Botulinum toxin A

Botulinum Toxin: What is it and how does it work?

- A vacuum dried purified protein
- Produced by the bacterium Clostridium botulinum
- Refined and measured for potency
- Frozen until use

Published usage's of Botulinum Toxin

- Achalasia
- Anismus
- Blepharospasm
- Brow Furrow
- Cervical Dystonia
- Essential Tremor
- Hemafascial Spasm
- Myofascial Pain syndrome
- VII Nerve Disorder
- Occupational Dystonia
- Pain
- Spasmotic Dystonia
- Strabismus
- Cerebral Palsy
- Multiple Sclerosis
- Stroke
- Traumatic Brain Injury

What is the Clinical effect of Botulinum toxin?

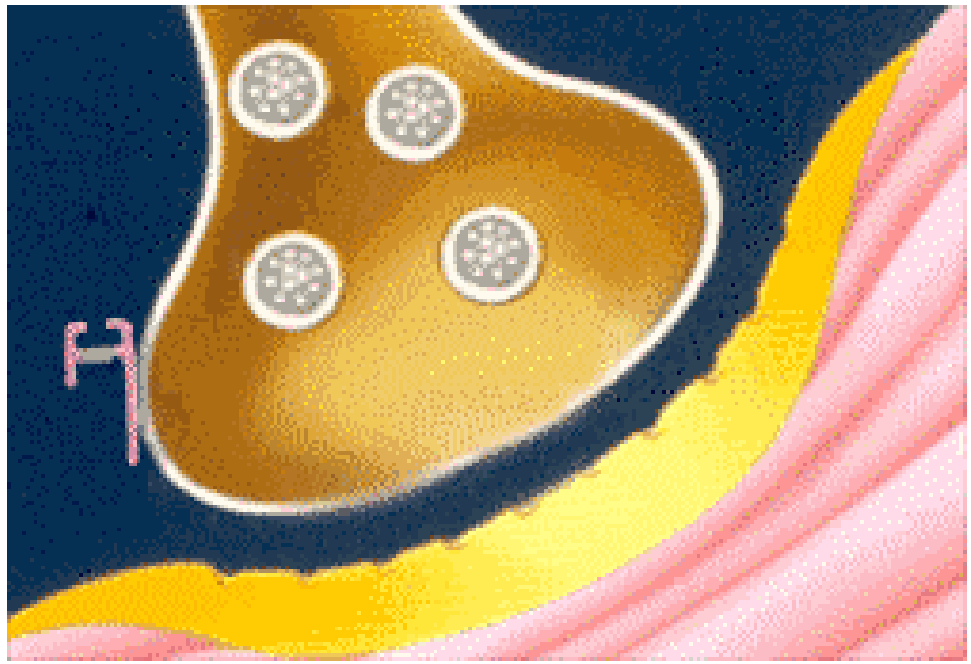
- Botulinum injections typically result in a dose dependant reduction of hyperactive muscle contraction
- Onset of clinical effect is 3 to 10 days; peaks in 2 to 3 weeks
- Lasts for 3 to 6 months
- Ultimately reversible

Botulinum toxin binds to the nerve

After injection, Botulinum toxin binds to the outside of the motor nerve ending in the preparation for internalization

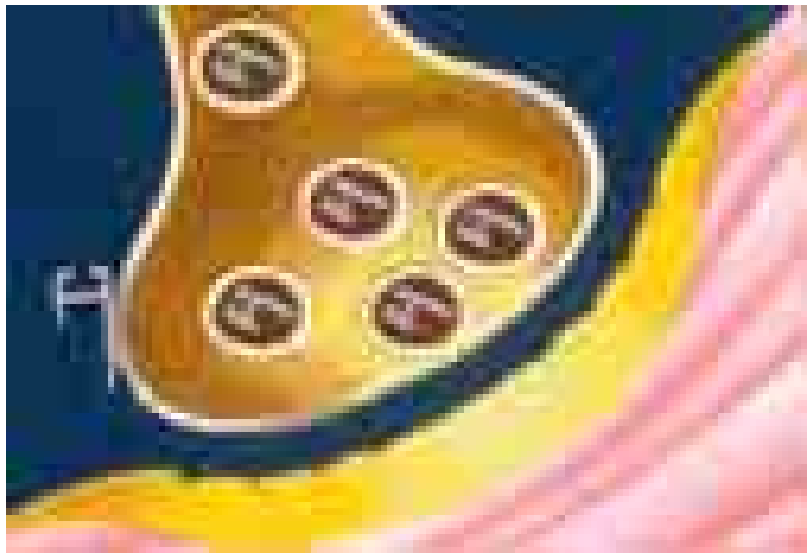
Internalization of Botox

Internalization is via the receptor endings. It must enter here to express its toxic effect



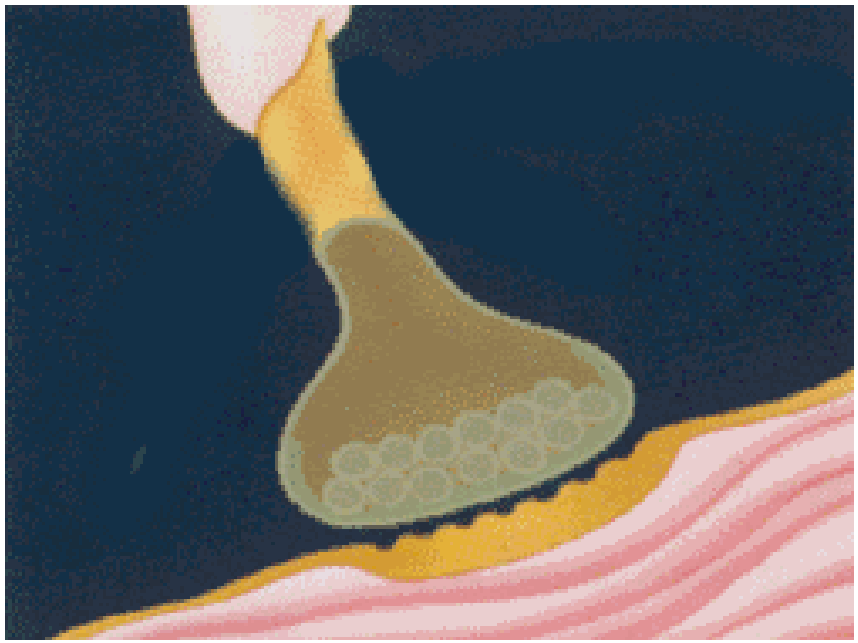
Botulinum Toxin acts very specifically

Its only chemical action is to enter the nerve endings in the muscle and block the nerve message there, preventing the the muscle to contract



Re-establishment of nerve to muscle transmission

- Nerve sprouting
- Nerve connection reestablished



Botulinum toxin Injections wear off

Toxin acts permanently on the nerve it enters, BUT the nerve is able to repair itself within a few months and regains its original function

Non-Responders

- Primary non-responder: demonstrates no response to initial injection of Botulinum toxin
- Secondary non-responder: demonstrates a relative or complete loss of efficacy at subsequent visit

Reasons for Non-Response (For Primary and Secondary Non-responders)

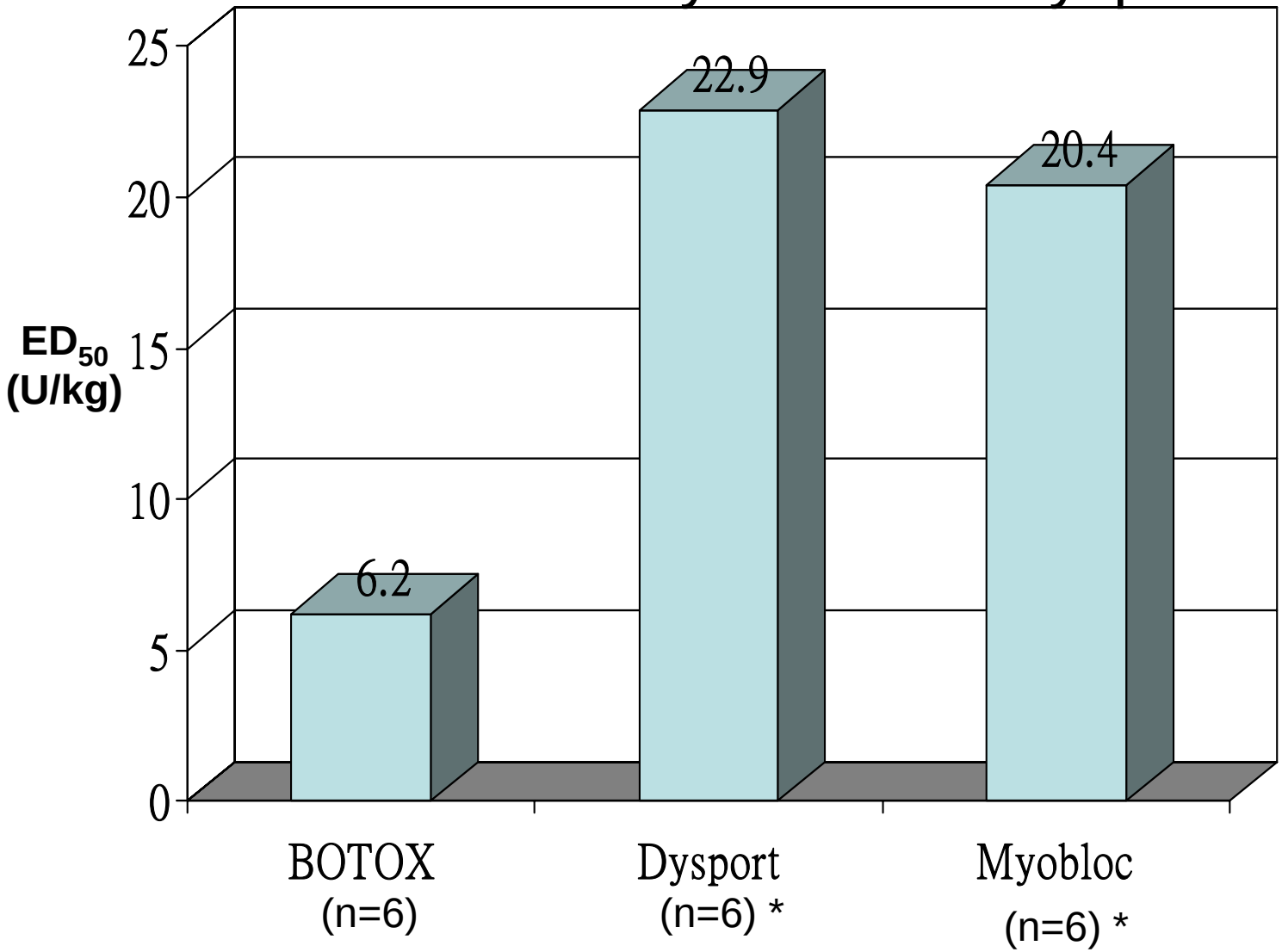
- Dose may be too low
- Muscles injected may require modification
- Weakness and/or atrophy present on exam with no functional benefit
- Change in pattern of muscle involvement during treatment
- Inappropriate reconstitution or storage of toxin
- Presence of neutralizing antibodies

Comparison of Product Characteristics

	BOTOX®	DYSPORT®	
Serotype	**A**	**A**	
Complex MW	**900 kDa**	**> 500 kDa**	
Package (units)	**100**	**500**	**2,**
Neurotoxin Protein (ng/vial)	**~ 5**	**12.5**	
Form	**Vacuum Dried**	**Lyophillized**	
pH	**~ 7**	**~ 7**	
Year of First Approval	**1989**	**1991**	

* Elan data. Literature reports largest complex for B is 500 kDa and largest complex for A is 900 kDa

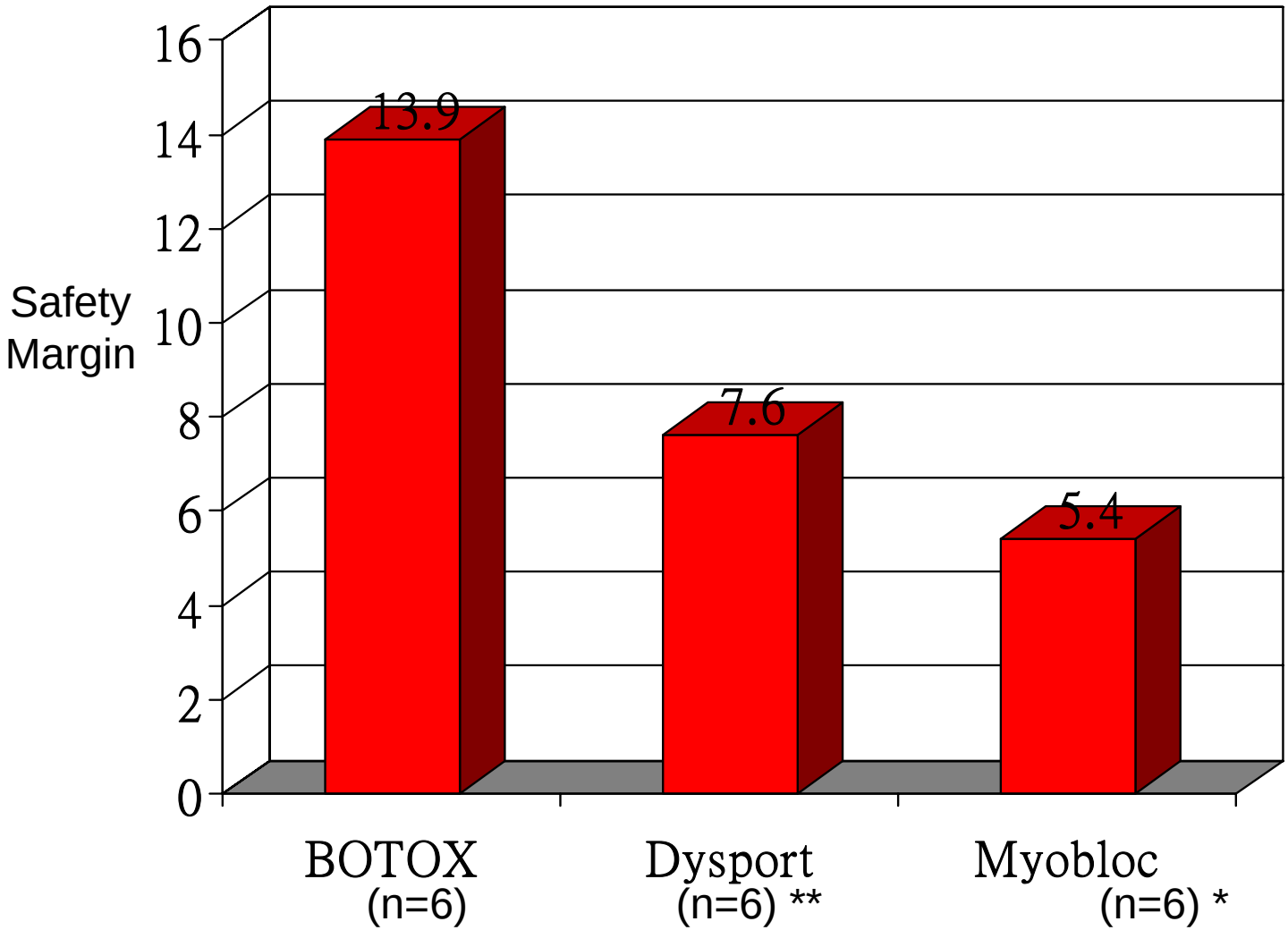
DAS (Digit Abduction Score) Efficacy Comparison Summary:
BOTOX® > Myobloc™ > Dysport®



Compared with BOTOX:
*** p < 0.0001**

Data from:
Toxicon 39 (2001) 1815-1820 .
Toxicon. 40 (2002) 81-86

Summary: Intramuscular Safety Margin Varies with Serotypes and Preparations:



Compared with BOTOX® :

*** p < 0.05**
**** p < 0.01**

LD/ED

Data from:
Toxicon 39 (2001) 1815-1820 .
Toxicon. 40 (2002) 81-86

Preclinical Results Consistent With Clinical Experiences

Preclinical Observation

- Diffusion margin
- Safety margin

Clinical Experience

- Dysphagia in CD
- Dry mouth and dyspepsia
- Dysphagia post lower limb injection

Botulinum Toxin CD Studies - Local AE

	Dysport® Fuewe				NeuroBloc®/MyoBloc® 089				301			302		BOTOX® 140		503	
Units	PBO	250	500	1000	PBO	2500	5000	10000	PBO	5000	10000	PBO	10000	PBO	Current - Vistabel 125	Original - Vistabel 150	Current - Vistabel 150
N	20	19	17	18	30	31	31	30	36	36	37	38	39	82	88	133	
Dysphagia	10	21	29	39	0	16	10	27	3	11	22	5	28	4	7	8	16
Dry Mouth	5	21	18	33	3	3	10	33	3	14	24	3	44	0	1	0	0
Inj Site Pain	10	5	18	28	10	16	19	17	8	6	11	8	18	0	0	3	1
Neck Weak	0	11	12	56	0	0	0	0						0	1	7	0
Fatigue	5	16	12	17	0	3	3	7				5	8	0	0	0	0

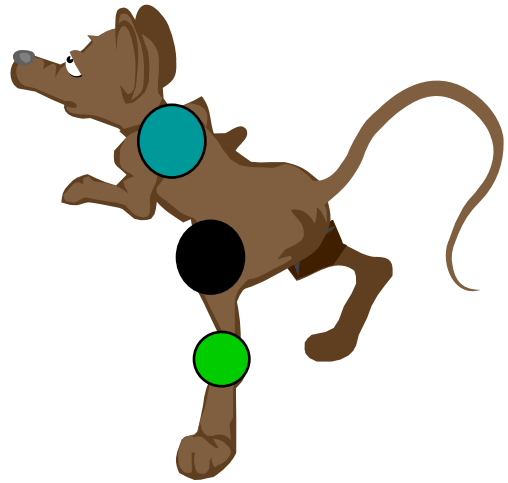
Neck weakness reported for BOTOX were "muscle weakness".
140: Double-blind, placebo-controlled original BOTOX. AE's reported for Dbl Bld.
503: European cross-over of original and current BOTOX. AE's reported are for Pd. I

Botulinum Toxin CD Studies - Sys AE

	Dysport® Fuewe				NeuroBloc®/MyoBloc® 089				301			302		BOTOX® 140		503	
Units	PBO	250	500	1000	PBO	2500	5000	10000	PBO	5000	10000	PBO	10000	PBO	Extract - Mean 243	Original - Mean 195	Current - Mean 195
N	20	19	17	18	30	31	31	30	36	36	37	38	39	82	88	133	
Dysphagia	10	21	29	39	0	16	10	27	3	11	22	5	28	4	7	8	16
Dry Mouth	5	21	18	33	3	3	10	33	3	14	24	3	44	0	1	0	0
Inj Site Pain	10	5	18	28	10	16	19	17	8	6	11	8	18	0	0	3	1
Neck Weak	0	11	12	56	0	0	0	0						0	1	7	0
Fatigue	5	16	12	17	0	3	3	7				5	8	0	0	0	0

Neck weakness reported for BOTOX were "muscle weakness".
140: Double-blind, placebo-controlled original BOTOX. AE's reported for Dbl Bld.
503: European cross-over of original and current BOTOX. AE's reported are for Pd. I

Why Is There A Difference?



- Serotype
  - “Acceptor” distribution
- Complex size
  - LL (900 kDa) vs L (700 - 500 kDa)
- Formulation
  - pH, excipients

Dysport® Diffusion and Safety Margin May Be Related To Its Bulk Toxin

- Column purification of complex
  - Hambleton, P. et al, 1981. In Lewis GE et al Biomedical Aspects of Botulism. pp247
- Poor separation of LL (19S) and L (16S) forms
  - Inoue, K. et al. Infec Immun 1996:64;1589
- May explain extra diffusion
  - Preclinical & Clinical

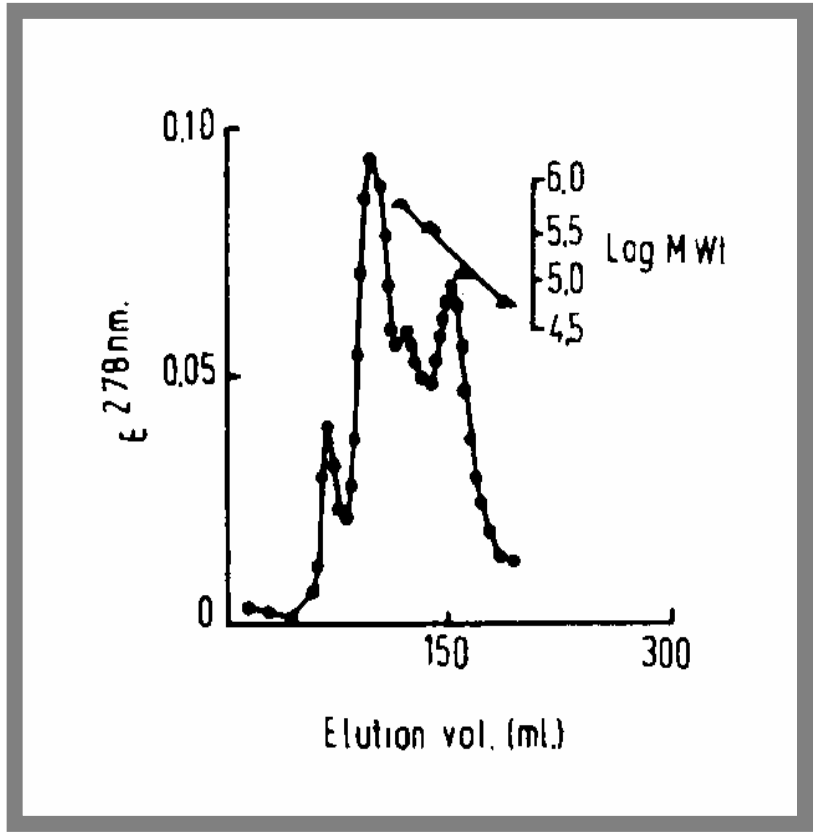
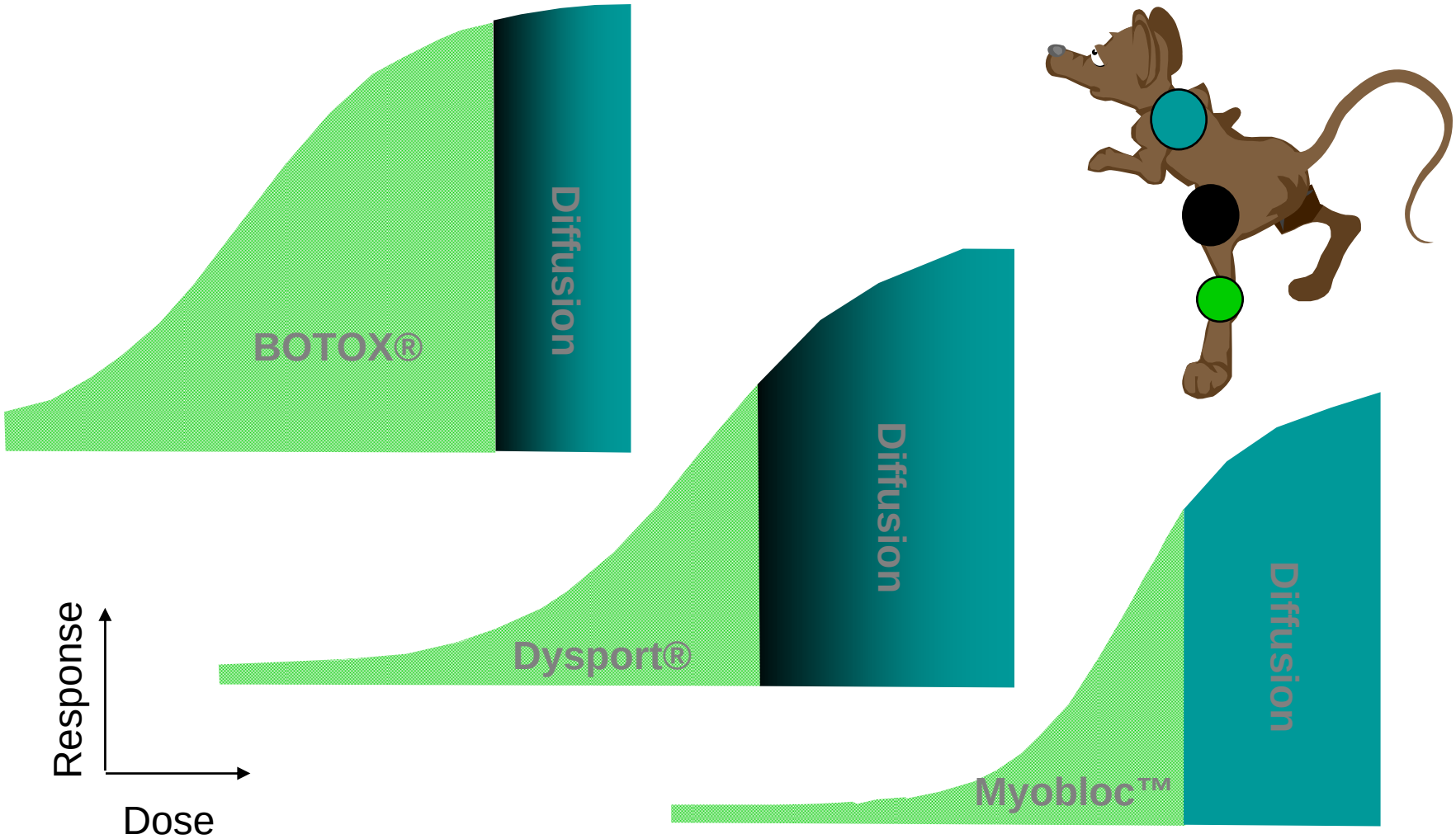


Figure 1

Potential Consequence of Diffusion

- Loss of therapeutic molecule from injection site
- Target muscle does not achieve maximum effect
  - Reduced peak effect and/or duration

Summary of Local IM Efficacy vs Inter-Muscular Diffusion and Safety in Mice



Data submitted for 2003 AAN

Is Diffusion Important?

- Need for maximal local effect
  - Maximum duration of action
- Minimal or no systemic effect
  - Local weakness
  - Distal weakness

Therapeutic Window Summary

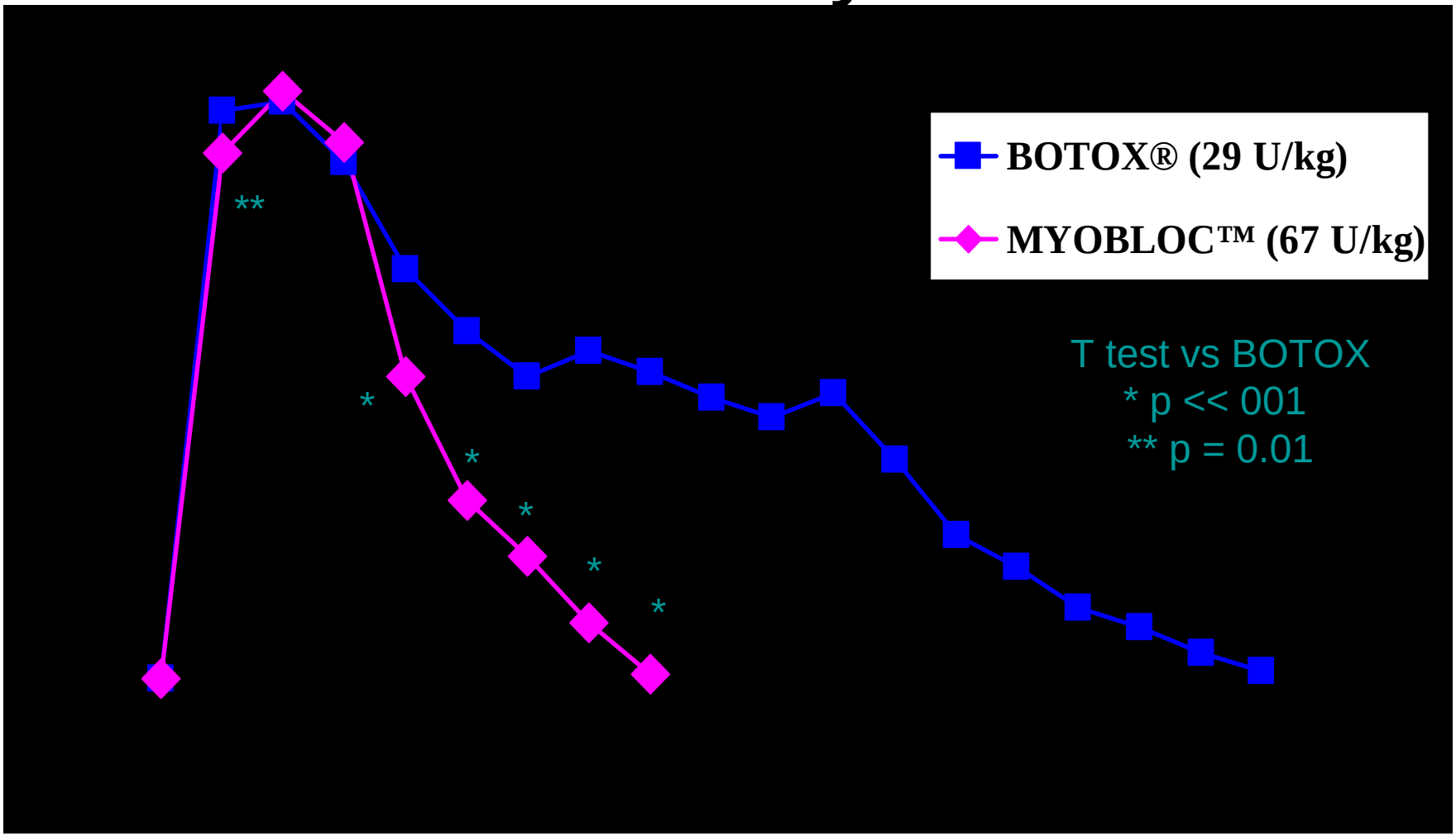
- Diffusion or Safety Margin
  - Local effect vs diffusion
    - Distal (limb) or systemic (general weakness)
- Each Botulinum Toxin Product Unique
  - Control of treatment
    - Maximize local effect
    - Minimize loss from target site
  - Simple dose conversion between products is misleading & not recommended

Duration of Action Comparison

- BoTx-A longer than BTX-B
  - In vitro (Dolly)
  - In vivo (Allergan)
  - Clinical EMG (Sloop)
- Data consistent between systems

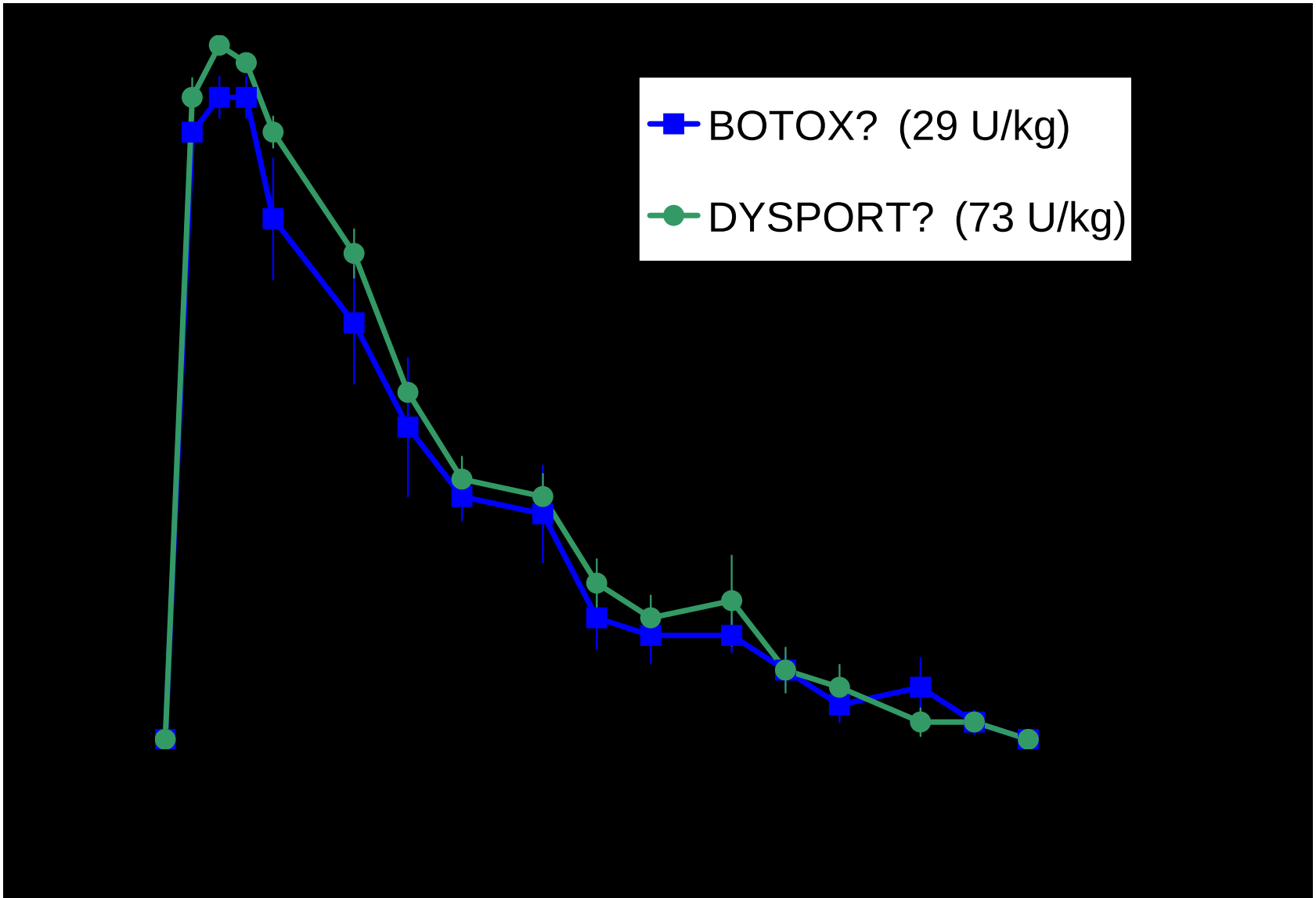
Duration of BoTx-A > BTX-B

Duration Comparison in Mice*
BOTOX® > Myobloc™



* Mean of 3 experiments. Accepted Toxicon 2002

Duration of Action: BOTOX® vs. Dysport®



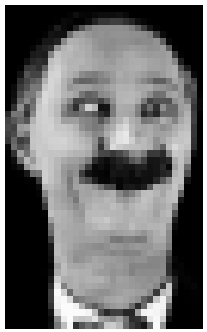
Antigenic Potential Assessment

- **Immunogenicity of serotypes**
- **Cross reactivity between serotypes**

Maintaining Long-Term Response

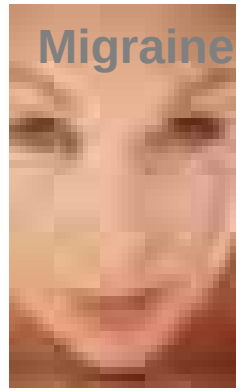
Importance of Preventing Neutralizing Antibody Formation

Patients Depend on Continuous Therapy

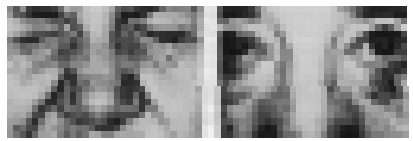


Strabismus

Cerebral Palsy



Cervical Dystonia



Blepharospasm

Why Are Neutralizing Antibodies Important?

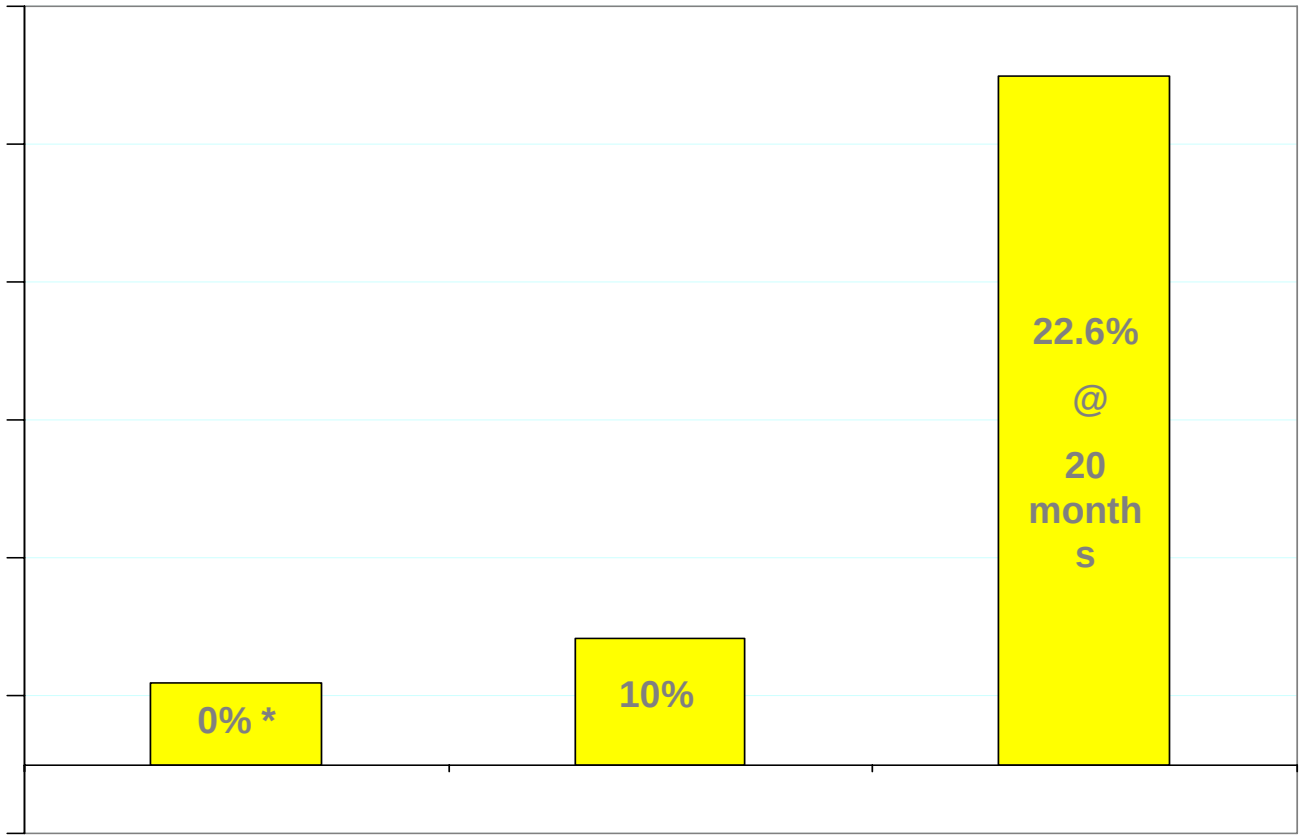
- **Loss of therapeutic effect**
  - **Patients must seek alternatives**
- **Therefore important to minimize risk of antibody formation**
  - **Use lowest dose in Units**
    - **Equals less neurotoxin protein exposure (ng)**
  - **Use longest interval between injections**
    - **Determined by the duration of action**

Comparison of Product Characteristics

	BOTOX®	DYSPORT®	
Serotype	**A**	**A**	
Complex MW	**900 kDa**	**> 500 kDa**	
Package (units)	**100**	**500**	**2,**
Neurotoxin Protein per Vial (ng)	**~ 5**	**12.5**	
Form	**Vacuum Dried**	**Lyophilized**	
PH	**~ 7**	**~ 7**	
Year of First Approval	**1989**	**1991**	

* Elan data. Literature reports largest complex for B is 500 kDa and largest complex for A is 900 kDa

Estimated Neurotoxin Protein Exposure for Cervical Dystonia Patients per Treatment Cycle



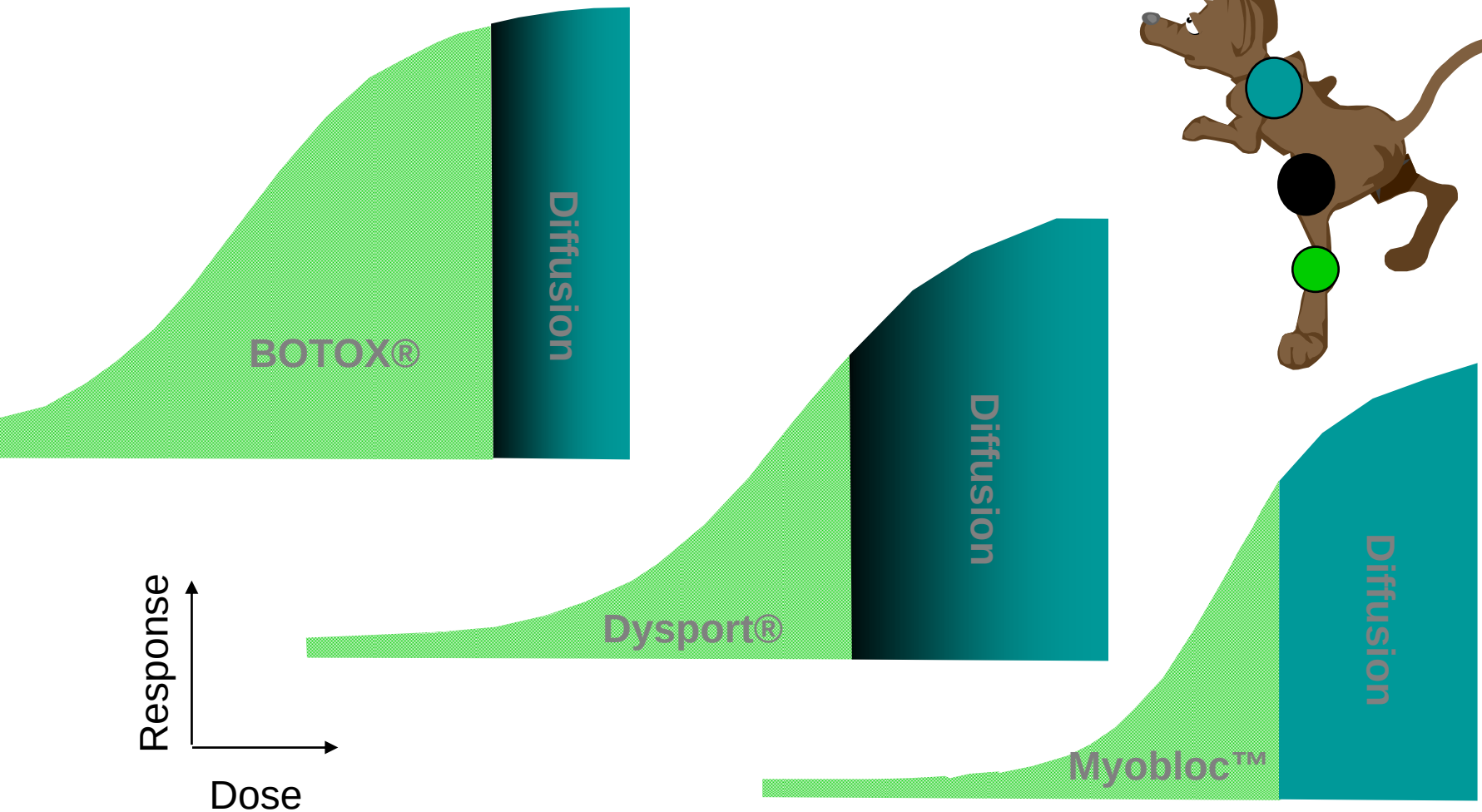
Dose from study →	BOTOX® 236 U (20 u/ng)	DYSPORT® 732 U (40 u/ng)	Type B (Elan) 10,000 U (100 u/ng)
	5 ng/vial	12.5 ng/vial	50 ng/5000 unit vial

* Percent patients with neutralizing antibodies. Current Botox experience. PI states 17%, based on CD patients treated with original Botox over several years

Pharmacology and Immunology Summary

- Botulinum toxin serotypes and preparations are unique
- Simple dose ratios require parallel dose response curves
  - Otherwise safety margins will differ
    - Local efficacy vs AE's
- Minimization of neutralizing antibody in patients is essential
  - Lowest neurotoxin protein (units) exposure per session
  - Longest interval between sessions

All Neurotoxin Products Are NOT The Same



Rehabilitation and the Use of Botulinum Toxin

Spasticity

In addition to increased tone other features frequently present are

- Increased muscle stretch reflexes
- Muscle spasms and clonus
- The “negative” symptoms of
  - loss of dexterity
  - weakness

Causes of Spasticity

- Stroke
- Cerebral Palsy
- Head Injury
- Spinal Cord Injury
- Multiple Sclerosis
- Others

Patterns of Spasticity

- **Upper Limb**
  - Adducted Shoulder
  - Flexed Elbow
  - Pronated Forearm
  - Flexed Wrist
  - Clenched Fist
  - Thumb in Palm Deformity
- **Lower Limb**
  - Equinovarus Foot
  - Flexed Toes
  - Knee Extension
  - Adducted Thighs
  - Flexed Hip

Treatment of Spasticity

- **Physical therapy** and modalities (heat,cold,serial cast, splints)
- **Oral medications** (diazepam, baclofen, dantrolene sodium)
- **Local measures** (nerve phenolisation, botulinum toxin)
- **Intrathecal** medication
- **Surgery** of various types

Goals of Rehabilitation Therapy with Neurotoxin

- **Improved function**
  - mobility and ambulation, transfers, seating & positioning, balance, sexuality, energy demand reduction
- **Increased ease of care**
  - dressing, feeding, hygiene and bathing,
- **Positioning**
  - prevention or treatment of musculoskeletal complications
- **Pressure sore reduction**
- **Decreased contracture problems**
- **Increased comfort**
  - pain reduction, sleep improvement, orthosis fit improvement
- **Cosmesis**
  - **improved body image and increased tolerance**
- **Improve rehabilitation participation**
- **Increase safety**

Patient Selection

- Dynamic contractures
- Weakening spastic limb/muscles will not compromise patient
- Antagonist muscles (capable of being recruited)

Advantages of Neurotoxin in Spasticity

- Effective in otherwise resistant spasticity
- Local effect with little or no systemic action
- Effects reversible
- May be improved with other treatments i.e. splinting, casting, physiotherapy
- Injections can be repeated (3 monthly)
- Few if any side effects, either local or systemic

Disadvantages of Neurotoxin in Spasticity

- Focal treatment only
- Short duration of action
- Repeated injections may be required

Injection Techniques

- Intramuscular injection
- Muscles identified by
  - surface anatomy
  - muscular stimulation
  - EMG
- Knowledge of anatomy and surface anatomy required
- Injections 3 months apart

Reasons for Lack of Benefit

- Dose may be too low
- Improper injection technique (ie, wrong muscles injected)
- Weakness and/or atrophy present on exam with no functional benefit
- Change in pattern of muscle involvement during treatment
- Inappropriate reconstitution or storage of toxin
- Presence of neutralizing antibodies

Post-Injection Treatment

- Stretch injected muscles
- Serial casting
- Splinting may be useful
- Strengthen and facilitate antagonists
- Reassess function and goals

Assessment

Clinical examination

Ashworth scale

Goniometry (mechanical, video analysis)

Functional assessment (e.g. FIM scale)

Ashworth Scale

0 No increase in muscle tone.

1 Slight increase in muscle tone, manifested by a catch and release or by minimal resistance through the remainder (less than half) of the range of motion (ROM) when the limb is moved in flexion or extension.

2 More marked increase in muscle tone through most of the ROM, but affected limb is easily moved.

3 Considerable increase in muscle tone - passive movement difficult.

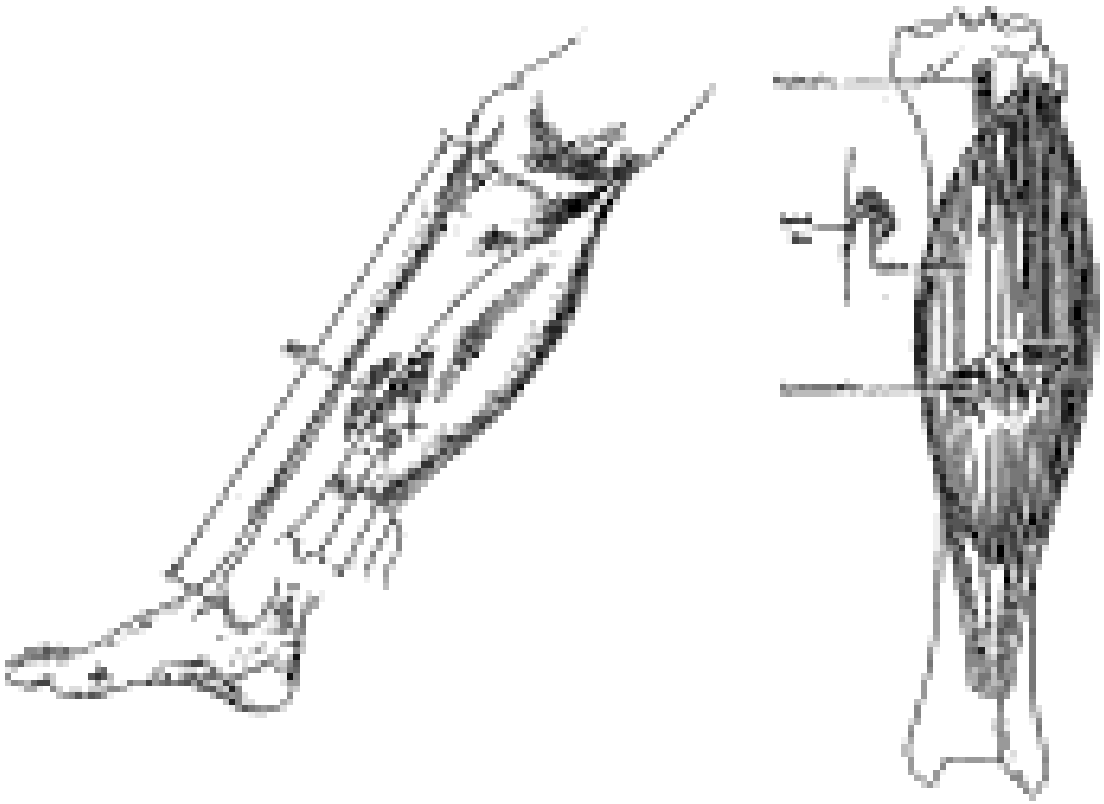
4 Limb rigid in flexion or extension.

BOTOX® Injection Protocols

Indication	Muscle	Dose
Ankle Equinovarus	Gastrocnemius (both heads)	75 units per head
	Soleus	75 units
	Tibialis Posterior	75 units

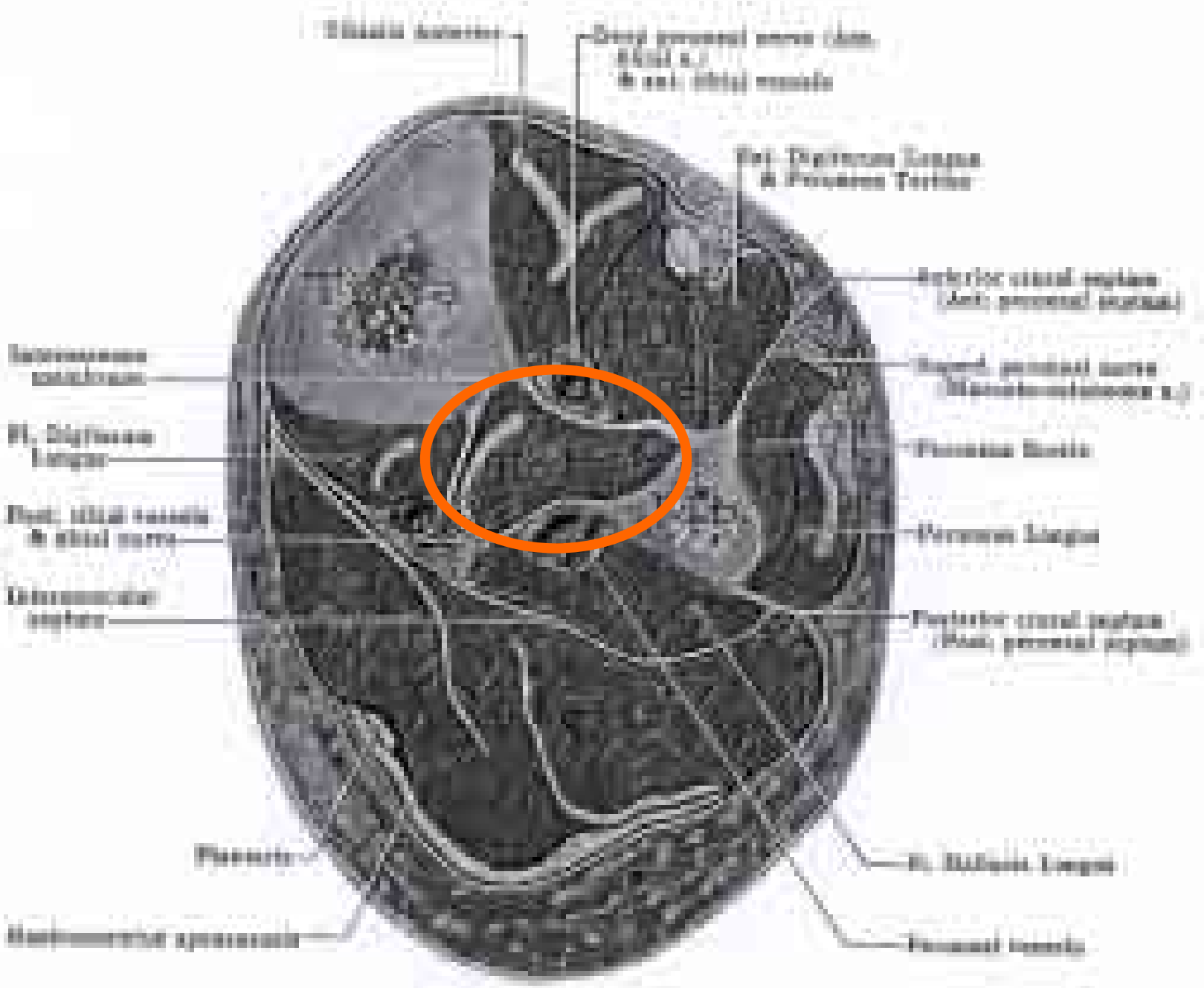
BOTOX® Injection Protocols

Indication	Muscle	Dose
Wrist & Finger flexion	Flexor Carpi Radialis	30-50 units
	Flexor Carpi Ulnaris	30-50 units
	Flexor Digitorum Profundus	50 units
	Flexor Digitorum Superficalis	50 units
	Adductor Pollicus	10 units
	Lumbricals	10 units



SITE: 1.
Position: Supine
Electrode insertion: Below the medial edge of mid-shaft tibia, just anterior to the belly of medial gastrocnemius and directed horizontally into soleus.

SITE: 2.
Position: Prone
Electrode insertion: Midline posteriorly at mid-calf, directed through the gastrocnemius tendon into soleus.



Ashworth Scale

	N	BTA dose	**Pre Inject**	**Post Inject**
Elbow	8	120	**3**	**2**
Wrist	12	0	**3.5**	**1.6**
Digits	10	20	**3.5**	**1.2**
Hip Flexor	2	150	**3.5**	**3**
Adductors	2	200	**3**	**2.5**
Ankle	12	175	**3.2**	**2.2**
EHL	4	75	**3**	**1**

Phenol Obturator Nerve Block

INTRODUCTION

- Selective obturator nerve block was first described by Labat in 1922
- In 1993 the inter-adductor approach was described by Wassef, which was further modified by Pinnock in 1996.

Main indications

- to treat hip joint pain
- To relieve adductor muscle spasm associated with hemi-or paraplegia.
- associated pain problems, grooming difficulty and mobilization problem.

Nerve block guidance

- When the neurolytic blockades are performed with the help of a *nerve stimulator* and/or *radioscopy*, they result in a cost-effective procedure

Contraindications

- Patient’s refusal
- presence of inguinal lymphadenopathy
- perineal infection
- haematoma at the needle insertion site

ANATOMY

- obturator nerve is a mixed nerve
- It provides motor function to the adductor muscles and cutaneous sensation to a small area behind the knee
- derived from the anterior primary rami of L2, L3 and L4

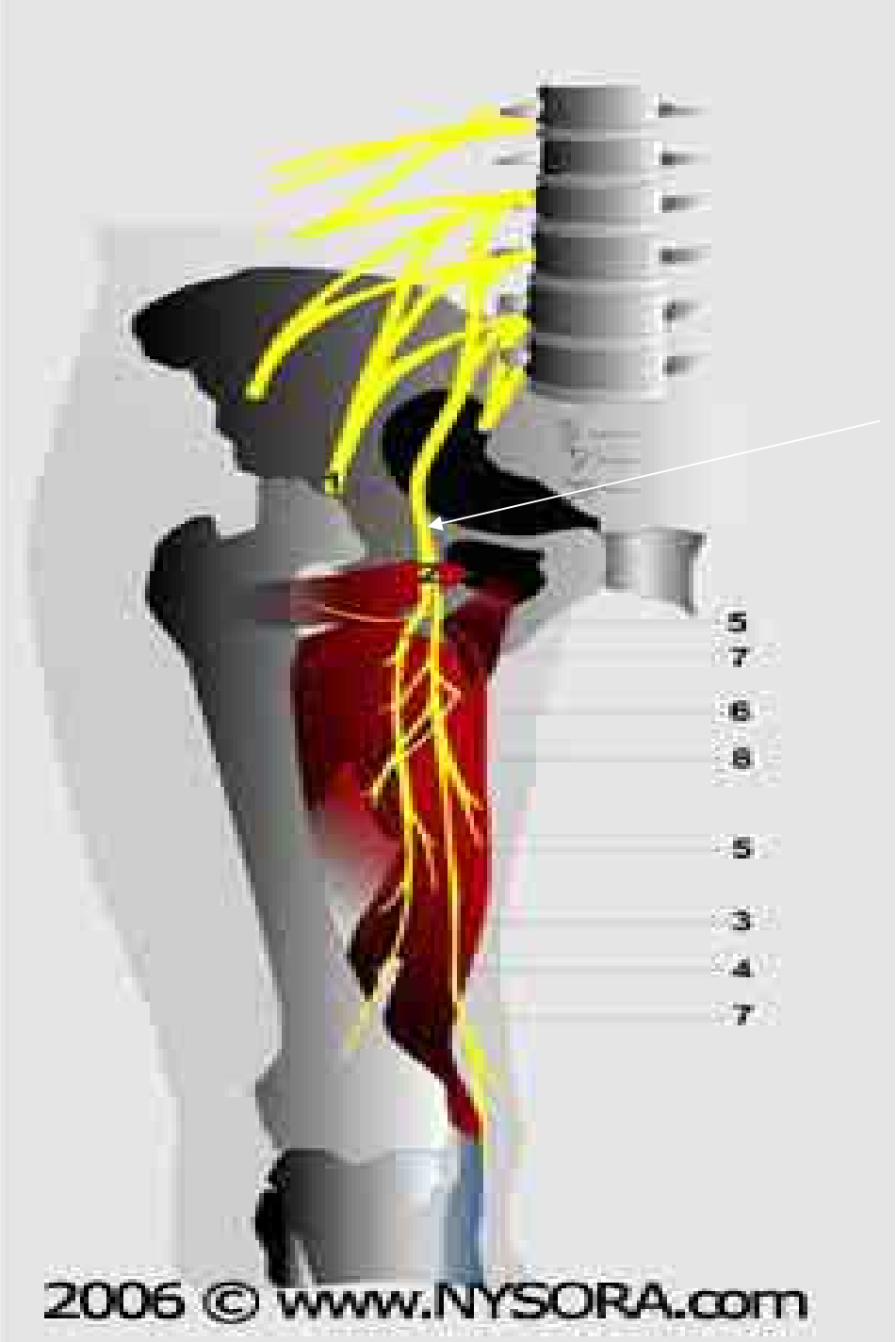


Figure 1. Anatomy of the obturator nerve

1. femoral nerve
2. *obturator nerve*
3. anterior branch
4. posterior branch
5. adductor longus
6. adductor brevis
7. adductor magnus
8. gracilis

Intrapelvic trajectory of the obturator nerve. After crossing under the iliac vessels, the obturator nerve **travels towards the obturator foramen via the lateral pelvic wall**. During this course the obturator artery and vein join the nerve, forming the obturator neurovascular bundle

Distribution of the anterior and posterior divisions of the obturator nerve ***after exiting the obturator foramen.***

Saggital section demonstrating the relationship of the obturator nerve to the adductor muscles.

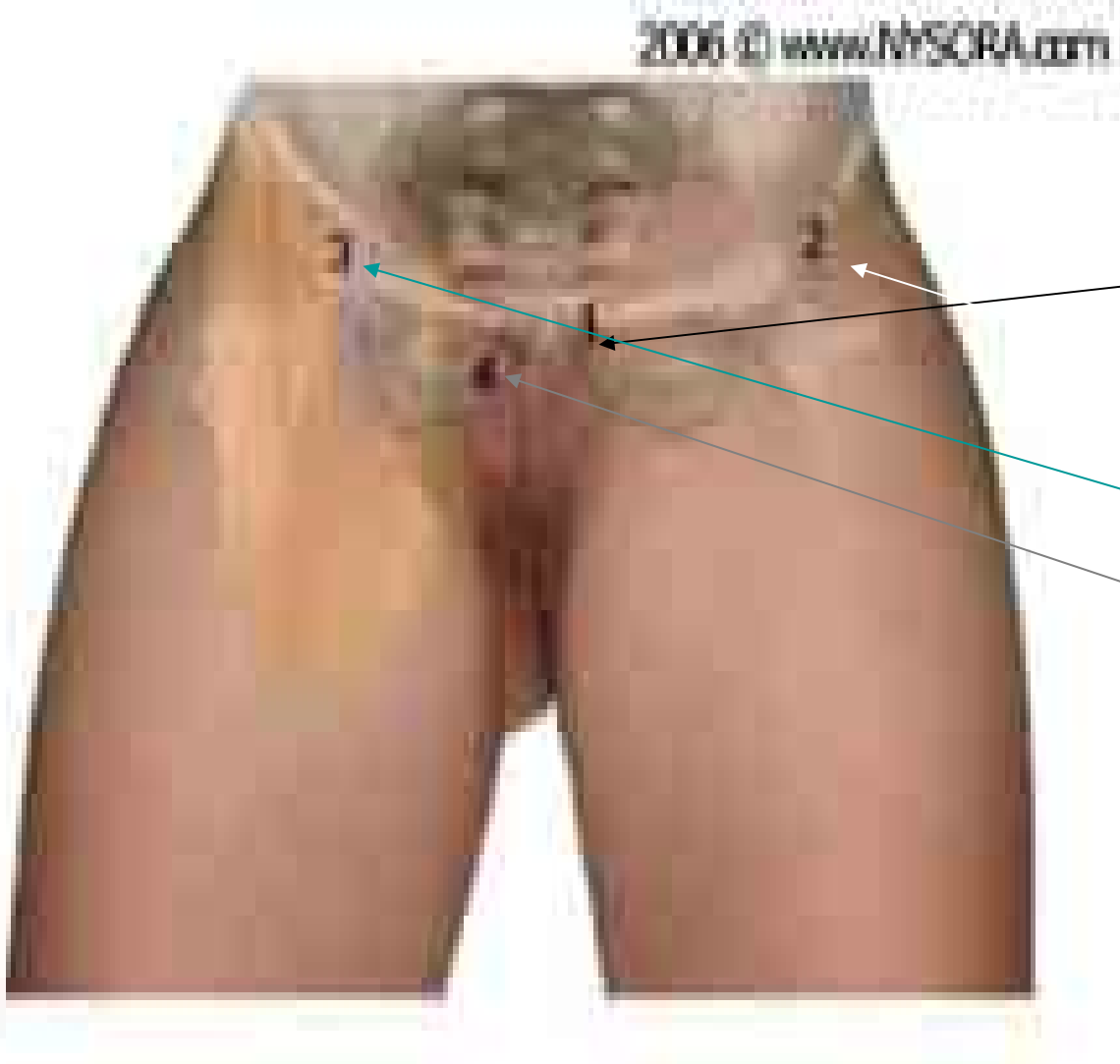
1. ***obturator nerve passing through the obturator canal***
2. obturator externus
3. pectineus
4. ***adductor longus***
5. adductor brevis
6. adductor magnus
7. medial femoral condyle
8. femoral nerve
9. sciatic nerve

EQUIPMENT

- Nerve Stimulator
- Insulated stimulating needle (5-8 cm, depending on the approach chosen)
- Local anesthetic
- Marking pen
- Ruler
- A 10ml syringe
- Disinfectant
- Sterile gloves

LANDMARKS

- Bony landmarks: *Anterior and superior iliac spine and pubic tubercle, inguinal ligament.*
- Vascular landmarks: *femoral artery, femoral crease*
- Muscular landmarks: *tendon of the abductor longus*



1. pubic tubercle
2. Anterio-superior iliac spine
3. femoral artery
4. tendon of the long adductor muscle.

Block evaluation

- Evaluation of an obturator block by sensory testing is difficult due to the variability in its sensory distribution (The most common sensory innervation is the skin in a small region located on the posteromedial aspect of the knee. A considerable overlap of cutaneous innervation exists.)

- Reduction in adduction strength is the most reliable means of demonstrating successful obturator nerve blockade

PERIOPERATIVE MANAGEMENT

- Patients must be warned that ambulation may be impaired due to the blockade of the thigh adductors.

Interadductor approach to obturator nerve blockade for spastic conditions of adductor thigh muscle

Wassef, M R.

Regional Anesthesia.

18(1):13-7, 1993 Jan-Feb.

BACKGROUND AND OBJECTIVES

- to describe an approach for the management of adductor muscle spasm associated with multiple sclerosis and paraplegia.

METHODS

- needle insertion behind the upper end of the adductor longus muscle
- the needle was directed ***laterally, with slight upward and posterior inclination***, toward the obturator canal.

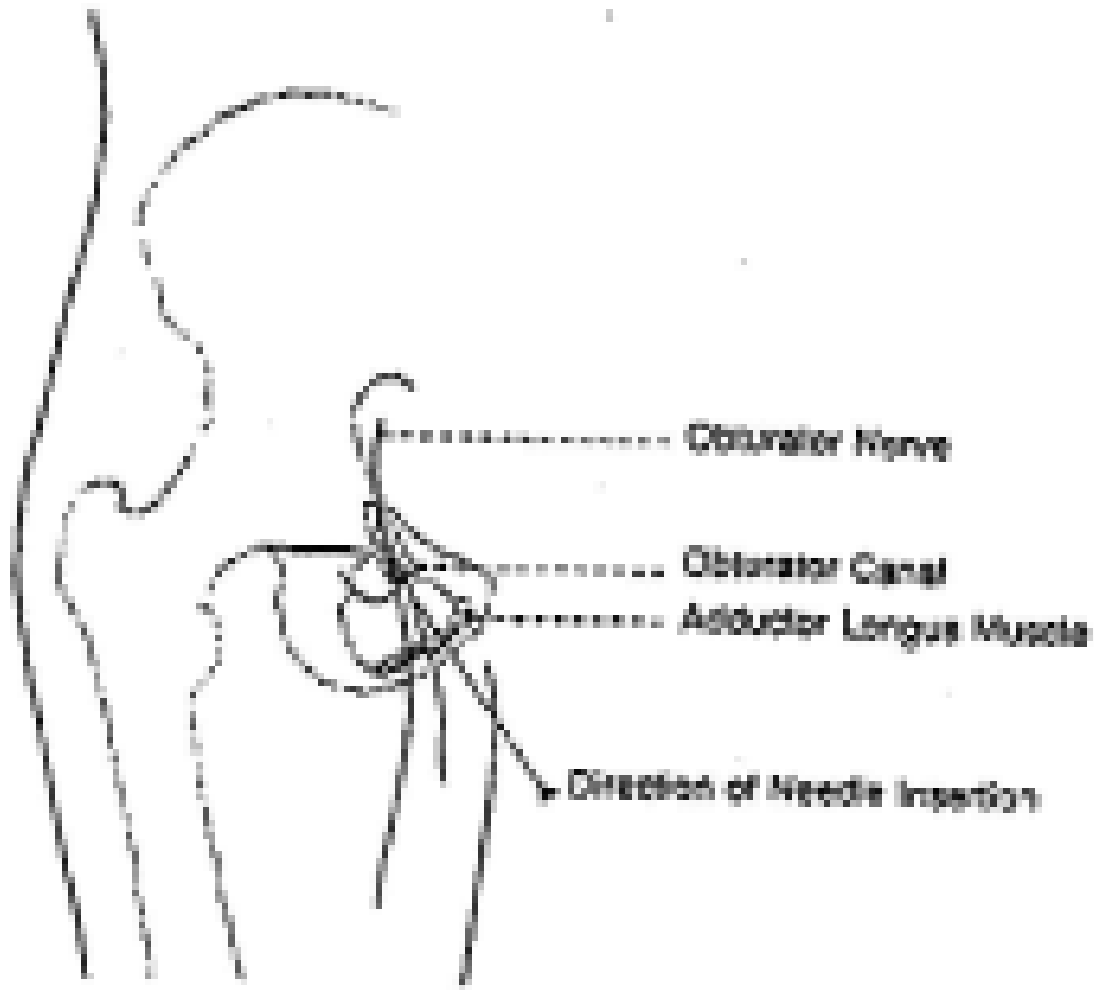


FIG 1. The intraadductor approach to the obturator nerve block. The diagram depicts the block needle direction and alignment with the obturator canal. Note the two branches of the obturator nerve, within the obturator canal, immediately separate at its exit.

Evaluation of the efficacy

- 1. its success rate
- 2. the degree of alleviation of muscle spasm
- 3. the improvement of gait
- 4. the facilitation of nursing hygienic care

TABLE 1. *Demographic Data of Patients*

	Group A Interadductor Approach	Group B Traditional Approach
Patients	n = 10	n = 10
Sex ratio (M:F)	3:7	3:7
Age (years): mean (SE)	53.1 (±2.9)	59.1 (±2.3)
Range (years)	40–66	46–68
Multiple sclerosis	n = 3	n = 3
Paraplegia	n = 7	n = 7
Duration of disease (years)	16.1 (±1.7)	17.6 (±1.0)
Range (years)	10–25	12–22

(SE): standard error of the mean.

TABLE 2. *Characteristics of the Interadductor and the Traditional Approaches*

	Group A Interadductor Approach	Group B Traditional Approach
Number of blocks performed	86 (n = 10)	86 (n = 10)
Number of successful blocks	70 (n = 8)	52 (n = 6)
Percentage of block success	81.4%	60.5%
Depth of needle insertion (cm)	4.5 (±0.2)	4.6 (±0.2)
Range (cm)	4.0–6.0	3.5–5.5
Number of needle attempts for each successful block	4.7 (±0.9)	7.5 (±0.5)
Range	2–6	5–10

(SE): standard error of the mean.

TABLE 3. *Comparison between Patients Undergoing Intraductor (Group A) or Traditional (Group B) Approaches*

	Muscle Spasm Score		Hyphen Score		Cuff Score	
	Before	After	Before	After	Before	After
After block with local anesthetic						
Group A	3.5 ± 0.1	1.2 ± 0.1*	2.3 ± 0.1	1.4 ± 0.1*	3.0 ± 0	1.3 ± 0.1*
Number of blocks	84	84	37	37	12	12
Group B	3.5 ± 0.1	2.8 ± 0.1*	2.3 ± 0.1	1.9 ± 0.2*	3.0 ± 0	1.8 ± 0.2*
Number of blocks	40	40	20	20	8	8
P <		0.001		0.05		0.05
After block with Phenol						
Group A	3.3 ± 0.1	1.3 ± 0.1*	2.3 ± 0.2	1.1 ± 0.1*	3.0 ± 0	1.3 ± 0.3
Number of blocks	16	16	16	16	4	4
Group B	3.2 ± 0.1	1.7 ± 0.1*	2.3 ± 0.2	1.8 ± 0.2*	3.0 ± 0	1.5 ± 0.5
Number of blocks	12	12	12	12	4	4
P <		0.01		0.05		NS

TABLE 4. *Degree of Patient Discomfort*

	Minimal	Mild	Moderate	Severe
Interadductor (Group A)	40	30	10	20
Number of patients	4	3	1	2
Traditional (Group B)	00	10	30	60
Number of patients	0	1	3	6

TABLE 5. *Degree of Patient Satisfaction*

	Complete Satisfaction	Minor Reservation	Major Reservation	Dissatisfied
Interadductor (Group A)	70% (n = 7)	10% (n = 1)	00	20% (n = 2)
Traditional (Group B)	00	40% (n = 4)	40% (n = 4)	20% (n = 2)

- In comparison with the traditional approach, the success rate of inter-adductor approach and improvements were highly significant

Conclusion of this study

- The ***interadductor*** approach allows needle positioning inside the obturator canal, thus facilitating the blockade of the obturator nerve trunk before it branches.
- This approach proved to be successful, reproducible and without complications.

EBM of Botulinum toxin in Rehabilitation

BOTOX® for Lower Limb Spasticity Post Stroke

Study Design

Part I

- Double-blind, placebo-controlled randomised trial
  - 200 U or 300 U BOTOX® or matched placebo

Part II

- Open label follow-up
  - 200 U or 300 U BOTOX®

Inclusion Criteria

- A clinical diagnosis of stroke at least more than six weeks ago;
- Moderate (Grade 2) to severe (Grade 3) spasticity as per the Ashworth Scale at the ankle;
- A spastic equinovarus deformity, related to this stroke, impeding voluntary movement;

Study Design

Visit Schedule Part I

- 2 baseline visits (2-4 weeks apart)
- 4, 8, 12 and 16 weeks follow-up (or until patient's Ashworth Score returned to baseline)

Visit Schedule Part II

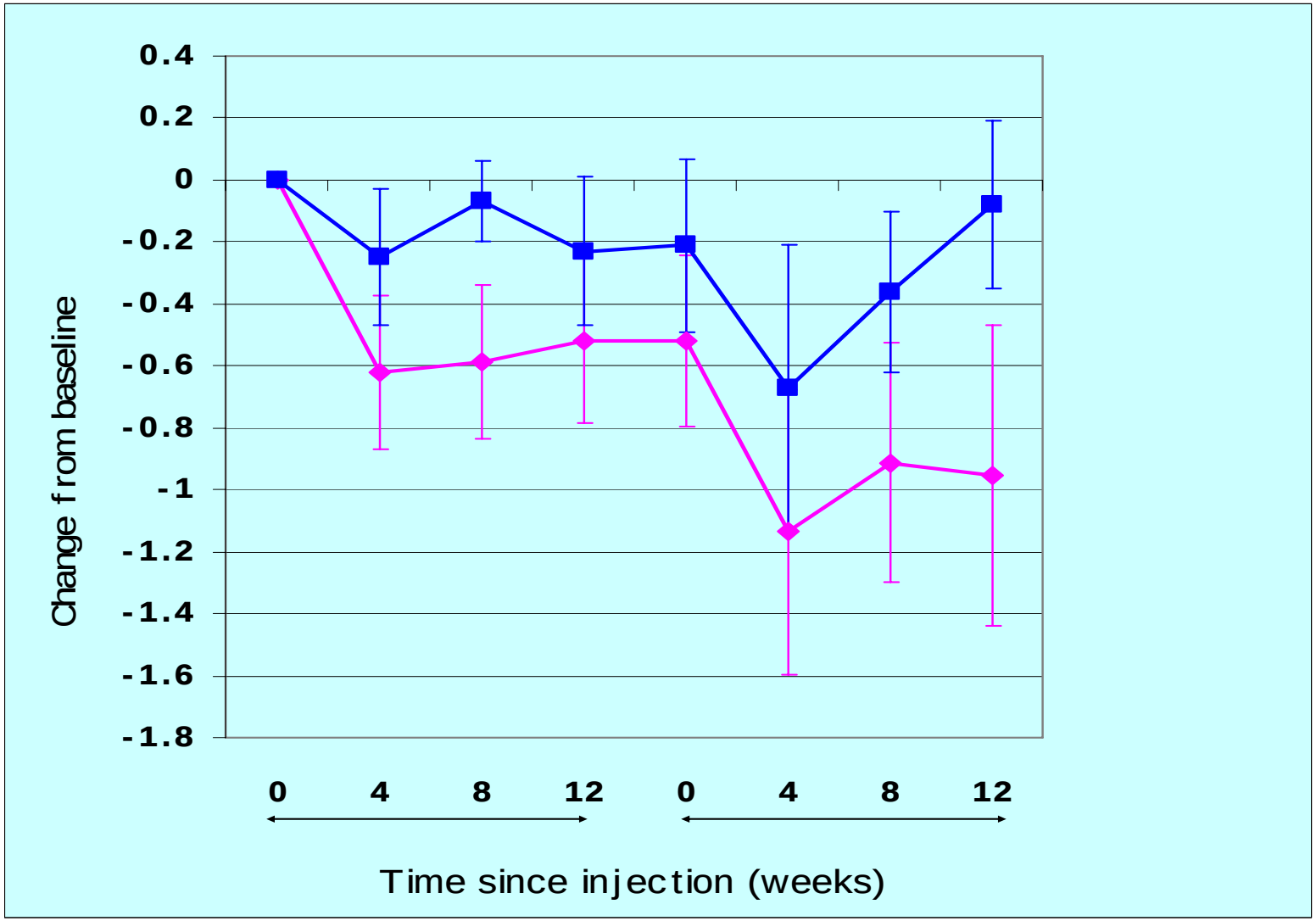
- Re-inject when Ashworth score returns to baseline (from 12 weeks)
- 4, 8 and 12 weeks follow-up

Injection Details

- All injections were performed by an Investigator under EMG guidance
- Injected
  - posterior tibialis; and
  - soleus; and
  - either the flexor digitorum longus or the medial gastrocnemius muscles

Assessments & Results

Ashworth Scores in Severe Patients



Ashworth Scores in Severe Patients

- In those patients who were **“severe”** (Ashworth score of 3) at baseline, one injection of BOTOX® reduced muscle tone at 8 weeks compared to placebo

- Two injections of BOTOX® reduced muscle tone at 4, 8 and 12 weeks compared to baseline.

Reduction of Ashworth Scores in All Patients

- Two injections of BOTOX® reduced muscle tone in **all** patients at 8 and 12 weeks compared to placebo then BOTOX®.
- Two injections of BOTOX® reduced muscle tone in **all** patients at 4, 8 and 12 weeks compared to baseline.
- A second injection of BOTOX® enhanced the reduction in muscle tone in all patients at 4, 8 and 12 weeks compared to a single injection.

Botulinum Toxin: Dosing and Dilution

LIPPINCOTT WILLIAMS & WILKINS

AMERICAN JOURNAL OF Physical Medicine & Rehabilitation

Volume 83(10) Supplement, October 2004, pp S30-S37

Objective

- To review important articles and selected abstracts on the use of botulinum toxin with emphasis on current clinical practices as they relate to ***dosing and dilution.***

Optimal dose

- The least amount of BTX needed to achieve a pre-determined outcome without causing an adverse effect
- clinical studies suggest that BTX dose is a crucial determinant of outcome

TABLE 1

Factors that affect dose selection of botulinum toxin

Patient-related factors
Severity of spastic hypertonia
Number of muscles involved
Chronicity of spastic hypertonia
Age and body mass
Previous response to botulinum toxin therapy
Concurrent therapy for spastic hypertonia
Clinician-related factors
Experience and Expertise
Second-hand experience
Other factors
Cost of therapy
Availability of adjunctive therapy

TABLE 3

Recommended or published Alarm doses for acoustic ligaments caused by various pathogenesis

Muscle	Dose, units	Reference
Upper limb		
Trabeculectomy	50–200	Ref. Hess[12]
Sinus surgery	25–400	Ref. Hess[13]
Laparoscopy (knee)	50–120	Ref. Hess[14]
Arthroplasty (negative)	75–150	Ref. Hess[15]
Trauma	100–200	
Biceps	50–400	Ref. Hess,[16] Lozano et al.,[17] Rivera et al.,[18] Hennessy et al.,[19] Wang et al.[20]
Scaphoid	100–200	Ref. Hess[21]
Psychomotor		Ref. Hess[22]
Forehead lines	15–12	Ref. Hess,[23] Palomo et al.[24]
Proximal epiphysis	50–80	Ref. Hess[25]
Flexor carpi radialis	25–400	Ref. Hess,[26] Brashear et al.,[27–29] Li Scalia et al.,[30] Sampaio et al.,[31] Wheeler et al.[32]
Flexor carpi ulnaris	100–25	Ref. Hess,[33] Brashear et al.,[34–36] Francisco et al.,[37] Li Scalia et al.,[38] Sampaio et al.,[39] Wheeler et al.[40]
Flexor digitorum superficialis	25–50	Ref. Hess,[41] Brashear et al.,[42–44] Li Scalia et al.,[45] Francisco et al.,[46] Sampaio et al.[47]
Flexor digitorum profundus	50–400	Ref. Hess,[48] Brashear et al.,[49–51] Francisco et al.,[52] Sampaio et al.,[53] Wheeler et al.[54]
Flexor pollicis longus	50–50	Ref. Hess,[55] Sampaio et al.,[56] Wheeler et al.[57]
Opponens pollicis	50–25	Ref. Hess[58]
Abductor pollicis	50–25	Ref. Hess[59]
Lumbricals	5–10 per head/digit	Ref. Hess,[60] Palomo et al.[61]
Lower Limb		Ref. Hess[62]
Quadriceps femoris(s)	50–200	Ref. Hess[63]
Hamstrings	50–300	Ref. Hess[64]
Hip adductor group	200–300	Ref. Hess,[65] Baron et al.[66]
Gastrocnemius	50–200	Ref. Hess,[67] Heinbaw et al.,[68] Brandt et al.[69]
Soleus	50–200	Ref. Hess,[70] Brandt et al.[71]
Tibialis anterior	50–400	Ref. Hess,[72] Brandt et al.[73]
Tibialis posterior	50–400	Ref. Hess[74]
Extensor hallucis longus	50–100	Ref. Hess et al.,[75] Jacquetand[76]
Flexor hallucis longus	50–75	Ref. Hess,[77] Jacquetand[78]
Flexor digitorum longus	50–100	Ref. Hess,[79] Jacquetand[80]
Flexor digitorum brevis	50–80	Ref. Hess[81]

TABLE 3

Published Dysport doses for spastic hypertonia

Muscle	Dose (units)	Reference
Upper Limb		
Subscapularis	250	Yelnik et al.[39]
Biceps	100–400	Ipsen Pharmaceuticals,[38] Bhakta et al.,[5,6] Hesse et al.[30]
Brachialis	220	Hesse et al.[32]
Brachioradialis	100	Bhakta et al.[5]
Flexor carpi radialis	150	Ipsen Pharmaceuticals,[38] Bhakta et al.[5]
Flexor carpi ulnaris	100–150	Ipsen Pharmaceuticals,[38] Bhakta et al.[5,6]
Flexor digitorum superficialis	150–300	Ipsen Pharmaceuticals,[38] Bhakta et al.[5,6]
Flexor digitorum profundis	150–200	Ipsen Pharmaceuticals,[38] Bhakta et al.[5,6]
Lower Limb		
Quadriceps		
Hamstrings		
Adductor group	300–1000	Hyman et al.[37]
Gastrocnemius	250–1000	Barbaud et al.,[33] Hesse et al.,[31,32] Johnson et al.[41]
Soleus	250–500	Barbaud et al.,[33] Hesse et al.,[31,32] Johnson et al.[41]
Tibialis posterior	250–350	Barbaud et al.,[33] Hesse et al.,[31,32] Johnson et al.[41]
Flexor digitorum longus	150–350	Barbaud et al.[33]

General Observations Regarding BTX Dosing

- At reported doses, Botox and Dysport are efficacious in decreasing muscle tone
- ***Limited*** data for upper and lower limb muscles have been reported by studies using Botox or Dysport to treat proximal limb spastic hypertonia.
- These studies included the ***distal muscles only***

General Observations Regarding BTX Dosing

- Higher doses seem to yield more improvement of muscle tone. However, dose-response relationships at doses higher than the ones studied are not known.
- Many studies used fixed doses of BTX, regardless of the severity of hypertonia. This does not reflect actual clinical practice in which the choice of dose is affected by various factors

General Observations Regarding BTX Dosing

- Outcome of studies may have been affected by failure to treat synergistic muscles contributing to the deformity.
- The majority of study participants were stroke survivors, limiting generalizability of study findings.
- Also, most studies included participants with a wide variation in illness duration

General Observations Regarding BTX Dosing

- Adjunctive therapies (ankle taping, electrical stimulation) may enhance outcome of treatment with BTX.
- There is limited evidence about the safety, efficacy, and cost-effectiveness of high doses of BTX commonly used in current practice.
- There is limited evidence about the safety and efficacy of the chronic use of BTX (e.g., use of >5 yrs)

General Observations Regarding BTX Dosing

- Currently, little is known about BTX-B dosing for spastic hypertonia.
- Dose comparability of Botox and Dysport have yet to be addressed in clinical studies.

General consensus

- Maximum dose of Botox is up to ***400 to 600 units per session***
- However, the safety and efficacy of routine use >500 units have not been systemically studied.

BTX Dilution

- In the last few years, clinicians have searched for ways to enhance the efficacy and cost-effectiveness of BTX therapy
- Advantages of smaller doses of BTX:
- 1. cost reduction
- 2. reduction in the amount used per session
- 3. prolonging efficacy beyond 3/12
- 4. decrease the risk of antibody formation

TABLE 4

Dilutions used in published studies

Botox	References
100 units/ml	Childers et al.,[4] Hesse et al.[11]
50 units/ml	Francisco et al.,[30] Kraali et al.,[14] Laßalle et al.,[22] Sampaio et al.,[31] Supattitada,[37] Wang et al.[43]
25 units/ml	Girlanda et al.[10]
20 units/ml	Gracies et al.[33]
Dysport	
50 units/ml	Hesse et al.[12]
100 units/ml	Bhakta et al.[5,6]
200 units/ml	Hesse et al.[12]
500 units/ml	Hyman et al.[17]

Ways to improve Botox efficacy

- injection technique (multiple site injections Vs motor endplate targeting)
- providing adjunctive therapy (e.g., electrical stimulation, ankle taping)
- increasing muscle activity post-injection
- modifying drug preparation with different diluent volumes

More dilute preparations

- results in increased drug preparation time
- increase discomfort because a higher volume and could potentially spread to adjacent muscles not targeted for treatment
- A way to decrease this discomfort is to limit volume of injection to **1 ml per site**

Animal studies

- Increasing the volume of BTX solution injected increases muscle paralysis
- Kim et al. showed in rabbits that more dilute preparation of BTX, with or without electrical stimulation, resulted in **more** gastrocnemius paralysis

Human studies (2 only)

- Preliminary evidence suggests that injecting a more dilute preparation of Botox results in better muscle tone reduction.
- The mechanism is unknown but may involve diffusion of the drug within the muscle, allowing it to affect a greater number of motor endplates

Role of Botulinum Toxin in Rehabilitation Medicine

Cochrane Library Review

Botulinum toxin type A in the treatment of lower limb spasticity in cerebral palsy (Review)

Ade-Hall RA, Moore AP

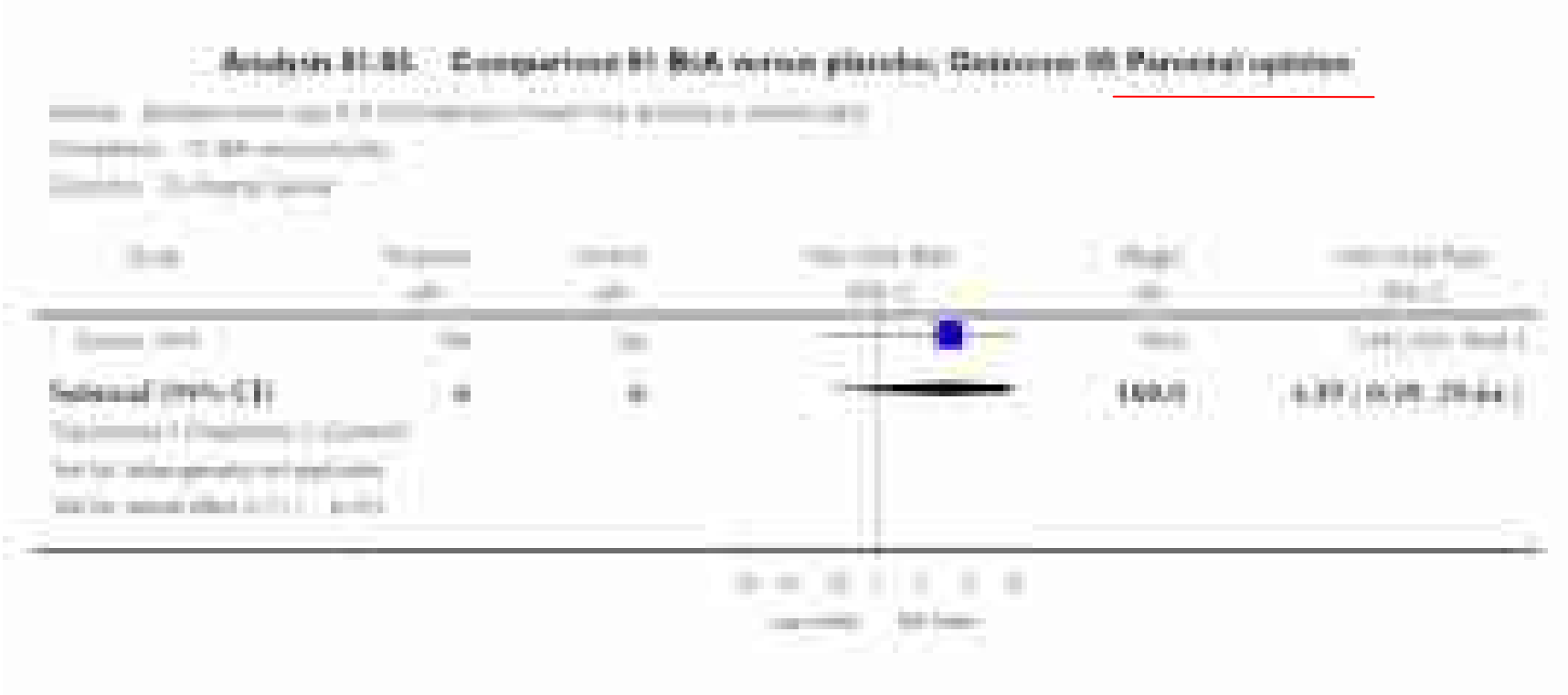
Characteristics of included studies

Study	Cases, 1986
Methods	Randomised controlled parallel group trial with an open-label design. Allocation by [illegible]
Participants	[illegible]
Interventions	[illegible]
Outcomes	[illegible]
Notes	
Risk of bias	[illegible]

Study	Davy 1999
Methods	[illegible]
Participants	[illegible]
Interventions	[illegible]
Outcomes	[illegible]
Notes	
Risk of bias	[illegible]

Study	Jones, 1994
Methods	[illegible]
Participants	[illegible]
Interventions	[illegible]
Outcomes	[illegible]


Analysis 61.01. Comparison 61 Bolt nerve placebo, Outcome 01 Disability responders



Analysis 02.01: Comparison of BIA versus conv. Outcome 01 Disability measures

Disability measures					
Study	FBS	40 gait analysis	GMFM	Muscle tone	Passive ankle ROM
Lucas, 1999	Sub - significantly improved p=0.006; Hip: n/s) Con - significantly improved p=0.003 Hip: n/s) No significant difference between groups (Mann-Whitney U test)	Ankle in foot lateral contact: No significant difference Ankle angle: No significant difference Maximal ankle moment p=0.01 Maximal plantar flexion p=0.01 (Mann-Whitney U test)			
Park, 1999	Sub - significantly improved p=0.001 (ANOVA) Con - significantly improved p=0.001 (ANOVA) No significant difference between groups (ANOVA)		Standing dimension Sub - significantly improved p=0.01 (ANOVA) Con - significantly improved p=0.01 (ANOVA) No significant difference between groups (ANOVA) Dynamic dimension Sub - significantly improved p=0.01 (ANOVA) Con - significantly improved p=0.01 (ANOVA) No significant		

Analysis 03.02. Comparison 03 BtA versus cast, Outcome 02 Impairment measures

Impairment measures					
Study	PBS	3D gait analysis	GMFM	Muscle tone	Passive ankle ROM
Casey, (1998)				BtA group no significant improvement p=0.07 (Sign test) Cast group no significant improvement p=0.22 (Sign test)	BtA group significantly improved p=0.003 (Wilcoxon) Cast group no significant improvement p=0.05 (Wilcoxon) No significant difference between groups (Mann Whitney U test)
Flett, (1999)				BtA - significantly improved p=<0.01 (MAS/5VA) Cast - significantly improved p=<0.05 (MAS/5VA) No significant difference between groups (MAS/5VA)	BtA - significantly improved p=<0.001 (SIAS/5VA) Cast - significantly improved p=<0.001 (SIAS/5VA) No significant difference between groups (SIAS/5VA)

Anti-spasticity agents for multiple sclerosis (Review)

Skoksgrinnen OT, Boggild M, Young C

Objectives

To assess the absolute and comparative efficacy and tolerability of anti-spasticity agents in MS patients.

Search strategy

We searched the Cochrane MS Group trials register (June 2003), the Cochrane Central Register of Controlled Trials (CENTRAL) (Issue 2, 2003), MEDLINE (January 1966 to June 2003), EMBASE (January 1988 to June 2003), bibliographies of relevant articles, personal communication, manual searches of relevant journals and information from drug companies.

Selection criteria

Double-blind, randomised, controlled trials (other placebo-controlled) or comparative studies of at least seven days duration.

Data collection and analysis

Two independent reviewers extracted data and the findings of the trials were summarised. Missing data were collected by correspondence with principal investigators. A meta-analysis was not performed due to the inadequacy of outcome measures and methodological problems with the studies reviewed.

Main results

Twenty-six placebo-controlled studies (using baclofen, dantrolene, tizanidine, benzodiazepines, sirolimus, sipatrectic, piracetam, dyrenium and tetrabenazine) and thirteen comparative studies met the selection criteria and were included in this review. Only fifteen of these studies used the Ashworth scale, of which only three of the eight placebo-controlled trials and seven of the seven comparative studies showed a statistically significant difference between test drugs. Spasms, other symptoms and overall impressions were only assessed using unvalidated scales and results of functional assessments were inconclusive.

Authors' conclusions

The absolute and comparative efficacy and tolerability of anti-spasticity agents in multiple sclerosis is poorly documented and no recommendations can be made on safe prescribing. The rationale for treating features of the upper motor neurone syndrome must be better understood and sensitive, validated spasticity measures need to be developed.

MS: Botulinum toxin Vs placebo

- 3 studies evaluating the use of botulinum toxin (BT) have been identified
- 2 (Snow 1990; Hyman 2000) evaluated participants with thigh adductor spasticity and one (Grazko 1995) evaluated 4 participants with LL spasticity and 1 participant with UL spasticity.
- Hyman 2000 reported a dose-ranging study, comparing 500, 1000 and 1500 units of Dysport with placebo.

Botulinum toxin (BT) versus placebo

- In Grazko 1995 , all 5 participants showed a two point improvement in Ashworth score which persisted for 1-3/12
- In Hyman 2000, there was a statistically significant improvement greater than placebo only in the maximum distance between the knees in the 1500 unit group at the primary end-point of 4/52 (but no statistically significant difference in the MAS)

Botulinum toxin (BT) versus placebo

- In Snow 1990, 7/9 participants treated with BT showed an improvement in spasticity score (product of tone and spasm scores) compared with 1/9 on placebo.
- 7 of nine participants showed an improvement in hygiene scores on BT, compared to 2 on placebo.

Combined effects of botulinum toxin and casting treatments on lower limb spasticity after stroke

Simona Farina, MD[a]
Claudia Migliorini, MD[a]
Marialuisa Gandolfi, MD[a]
Laura Bertolasi, MD[a]
Matteo Casarotto, MD[a]
Paolo Manganotti, MD[a]
Antonio Fiaschi, MD[a]
Nicola Smania, MD[a,c]

Optimal treatment of spasticity requires a combination of pharmacotherapy and muscle lengthening. We evaluated 13 stroke patients with equinovarus foot randomized to treatment with either botulinum toxin A (BTA) injection plus ankle-foot casting (n=6) or BTA alone (n=7). The tibialis posterior and calf muscles (range of BTA injection: 190 to 320 U) were treated in each patient. Castings were worn at night for four months. Each patient was examined before, and at two and four months after BTA injection using the static and dynamic baropodometric tests, the Modified Ashworth Scale and the 10-meter walking test. At two months, therapeutic effects were observed in both groups. At four months, the study group showed further clinical improvement, while the control group returned to baseline performance. Thus, prolonged stretching of spastic muscles after BTA injection affords long-lasting therapeutic benefit, enhancing the effects of the toxin alone.

Botulinum Toxin

Vs

Botulinum Toxin + Cast

Functional Neurology 2008; 23(2): 87-91

Table I. Socio-demographic and clinical features of patient groups.

Patients	Age	Sex	ESS	BI	Affected side	Duration of stroke (mths)	Total dose (Botox units)
Study group							
1	50	M	66	60	Right	18	260
2	55	M	72	70	Left	22	300
3	75	F	58	55	Right	8	300
4	50	M	73	70	Right	13	300
5	75	M	43	65	Right	21	260
6	67	F	66	70	Right	19	300
Mean	62		63	66.33			
SD	±11.83		±11.17	±6.16			
Control group							
7	70	F	58	70	Right	7	300
8	65	F	54	55	Right	19	260
9	72	F	66	60	Right	29	300
10	60	F	66	65	Left	12	300
11	70	M	58	70	Right	17	260
12	59	M	60	60	Left	23	300
13	63	M	62	65	Left	18	260
Mean	65.6		60.57	63.8			
SD	±5.2		±4.43	±5.56			

Results

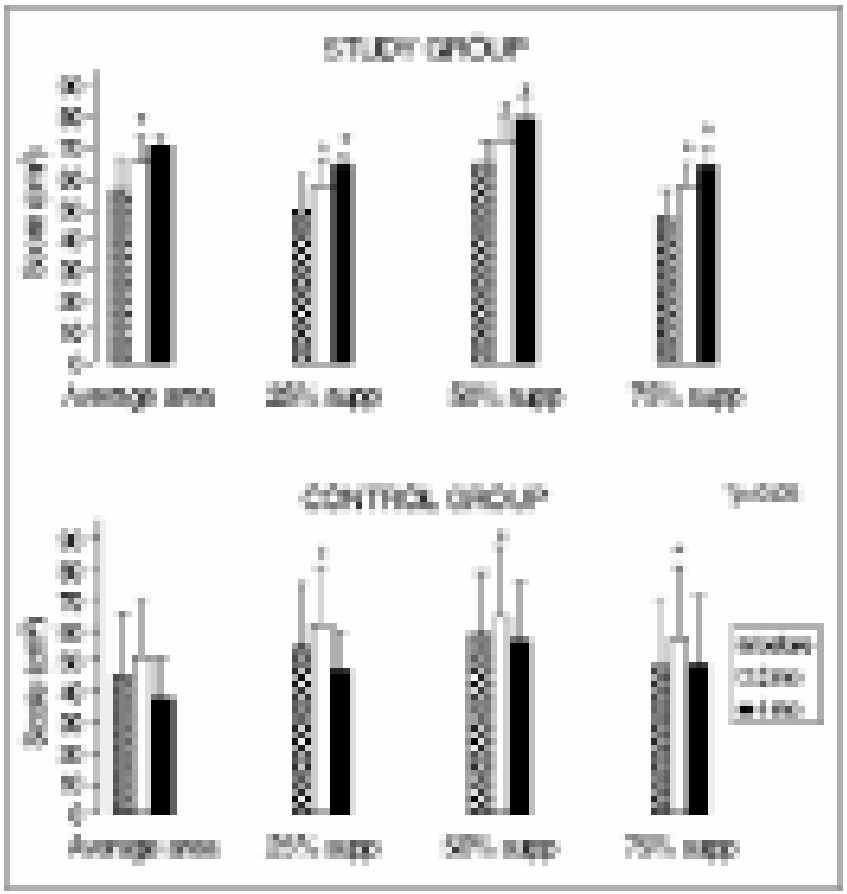


Figure 1 - Baropodometric footprint changes.

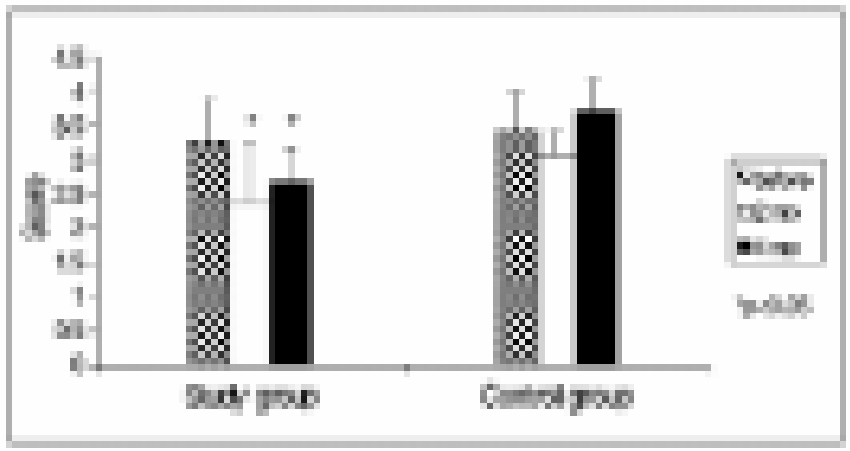


Figure 2 - Ashworth Scale results.

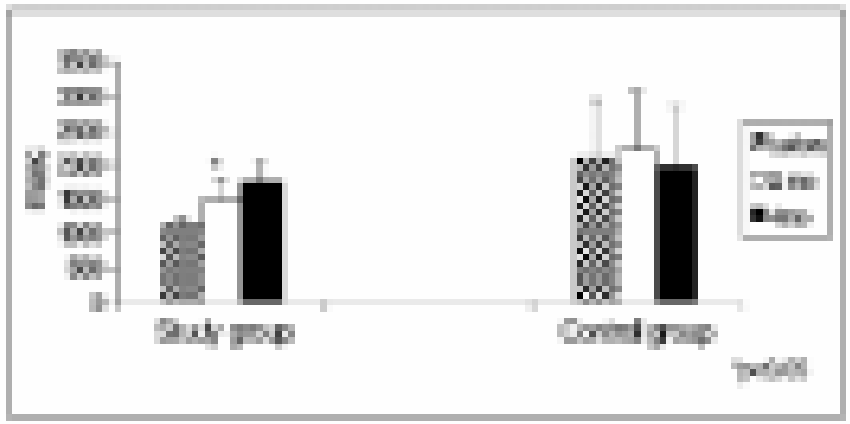


Figure 3 - Baropodometric changes in area at full load.

Table II. Differences (T1-T0 and T2-T0) in all outcome measures in study and control group.

Group		Ashworth Scale		Average area		Full load		25% support area		50% support area		75% support area	
		T1-T0	T2-T0	T1-T0	T2-T0	T1-T0	T2-T0	T1-T0	T2-T0	T1-T0	T2-T0	T1-T0	T2-T0
Study	Mean	-0.41	-0.58	9.61	14.53	368.66	636.66	7.66	13.5	7.33	14.33	8.5	15.66
	SD	±0.34	±0.34	±4.52	±13.26	±250.87	±265.28	±4.84	±5.89	±1.63	±3.39	±1.97	±5.20
Control	Mean	-0.21	0.429	6.995	-7.33	112.66	-112.66	7.16	-7.37	5.31	-1.78	8.77	1.28
	SD	±0.247	±0.460	±7.104	±7.95	±209.74	±181.16	±5.11	±5.45	±3.70	±2.82	±4.020	±3.25

Abbreviations: T0=before BTA injection; T1= two months after BTA injection; T2= four months after BTA injection.

Evidence-based systematic review on the efficacy and safety of botulinum toxin-A therapy in post-stroke spasticity

Summary. Background. Botulinum toxin type A (BoNTA) has been suggested as an effective anti-spastic drug. In this article, we summarized the data of randomized, placebo-controlled, double-blind trials and conducted a meta-analysis to assess if BoNTA is an adequate treatment for spasticity following stroke.

Objectives. To evaluate the relevant literature and assess the effectiveness and safety of BoNTA in (1) reducing spasticity based on mean change in the Modified Ashworth Scale (MAS) for upper and lower limb spasticity from baseline; (2) reducing spasticity based on the percent of patients having >=or= 1point(s) change in the MAS; (3) improving the patient's or caregivers' Global Assessment Scale (GAS); and (4) total adverse events.

Method. We selected all randomized, placebo controlled, double-blind clinical trials or previous meta-analyses evaluating the efficacy and safety of BoNTA (Botox® or Dysport®) for the treatment of spasticity in both upper and lower limbs after stroke. Validity assessment of studies was performed, and Revman 4.2.7 from Cochrane Collaboration and SPSS (statistical package for the social sciences), v 9.0, were applied for analysis.

Results. Overall analysis showed clinical improvement between baseline and 4–6 weeks after application of BoNTA of the patient's spasticity score using the MAS (weighted mean difference [WMD] = 0.87, 95% CI = 0.52–1.22). The odds ratio of the MAS spasticity score showing one or more points improvement at 4–6 weeks after giving BoNTA showed clinically significant improvement (OR = 4.5, 95% CI = 2.79–7.25). The odds ratio of having an improved GAS at 4–6 weeks after injecting BoNTA showed clinically significant improvement (Odds ratio = 5.85, 95% CI = 3.12–10.95). The odds ratio of having an adverse event during the entire study did not show any significant difference between placebo and BoNTA (odds ratio = 0.84, 95% CI = 0.55–1.28).

Reviewers' conclusions. BoNTA improves muscle tone in upper and lower limb spasticity following stroke. A global assessment of improvement was noted by the patients or the caregivers following BoNTA injection. BoNTA is considered a safe therapeutic agent.

Authors: R.L. Rosales, A.S. Chua-Yap

Journal of Neural Transmission

(2008) 115: 617-623

Table 1 Characteristics of studies included in the meta-analysis

Study ID	Methods	Participants	Interventions	Outcomes	Allocation concealment
Bakheit et al. (2000)	RCT, double-blind placebo-controlled dose ranging study	N = [illegible] patients p = [illegible] T1 = [illegible] T2 = [illegible] T3 = [illegible] UL spasticity	T1 = Dysport 500 U T2 = Dysport 1000 U T3 = Dysport 1500 U placebo	MAS functional outcomes ROM [illegible] Barthel index [illegible] adverse event	A
Bakheit et al. (2001)	RCT, double-blind placebo-controlled	N = [illegible] patients p = [illegible] T = [illegible] UL spasticity	T = Dysport 1000 U Placebo	MAS ROM Barthel index pain score [illegible] scale [illegible] adverse event	A
Brashear et al. (2002)	RCT, double-blind placebo-controlled	N = [illegible] patients p = [illegible] T = [illegible] UL spasticity	T = Botox [illegible] U Placebo	MAS functional outcomes [illegible] [illegible] [illegible]	A
Burbaud et al. (1996)	RCT, double-blind placebo-controlled	N = [illegible] patients p = [illegible] T = [illegible] LL spasticity	T = Dysport 1000 U Placebo	MAS gait velocity [illegible] score [illegible] scale	A
Childers et al. (2004)	RCT, double-blind placebo-controlled	N = [illegible] patients P = [illegible] T1 = [illegible] T2 = [illegible] T3 = [illegible] UL spasticity	T1 = Botox [illegible] U T2 = Botox [illegible] U T3 = Botox [illegible] U Placebo	MAS adverse event [illegible] pain scale [illegible] FIM [illegible]	A
Hesse et al. (1998)	RCT, double-blind placebo-controlled	N = [illegible] patients p = [illegible] T1 = [illegible] T2 = [illegible] T3 = [illegible] UL spasticity	T1 = Dysport 1000 U plus electrical stimulation T2 = Dysport 1000 U without stimulation T3 = Placebo with electrical stimulation p = placebo without stimulation	MAS functional outcomes [illegible] adverse event	A
Pittock et al. (2003)	RCT, double-blind placebo-controlled	N = [illegible] patients p = [illegible] T1 = [illegible] T2 = [illegible] T3 = [illegible] LL spasticity	T1 = Dysport 500 U T2 = Dysport 1000 U T3 = Dysport 1500 U placebo	MAS pain scale walking velocity walking [illegible] [illegible] adverse events [illegible]	A
Simpson et al. (1996)	RCT, double-blind placebo-controlled	N = [illegible] patients p = [illegible] T1 = [illegible] T2 = [illegible] T3 = [illegible] UL spasticity	T1 = Botox [illegible] U T2 = Botox [illegible] U T3 = Botox [illegible] U Placebo	MAS [illegible] adverse event grip strength FIM [illegible] [illegible] pain assessment	A
Smith et al. (2000)	RCT, double-blind placebo-controlled	N = [illegible] patients p = [illegible] T1 = [illegible] T2 = [illegible] T3 = [illegible] UL spasticity	T1 = Dysport 500 U T2 = Dysport 1000 U T3 = Dysport 1500 U placebo	MAS pain assessment passive range of movement [illegible]	A

RCT: Randomised controlled trials; N total number of participants; p number of patients in placebo group; T number of patients on treatment group; UL upper extremities; LL lower extremities; MAS modified Ashworth scale; GAS global assessment scale; ROM range of movement; FIM functional independence measure.
Study quality/allocation concealment: A = high quality; B = risk of moderate bias; C = high risk of bias.

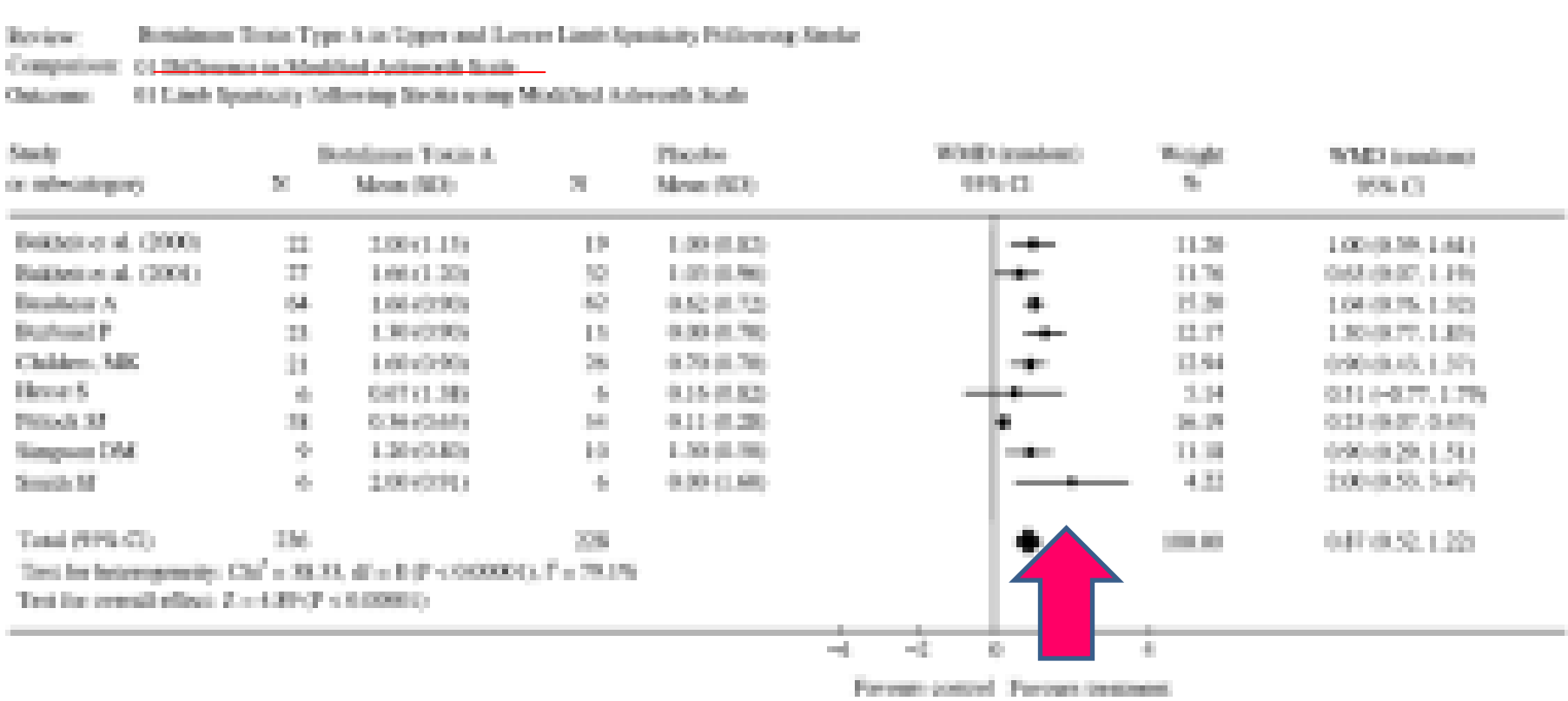


Fig. 1. Mean change in MAS after BoNT-A treatment at 4–6 weeks follow up

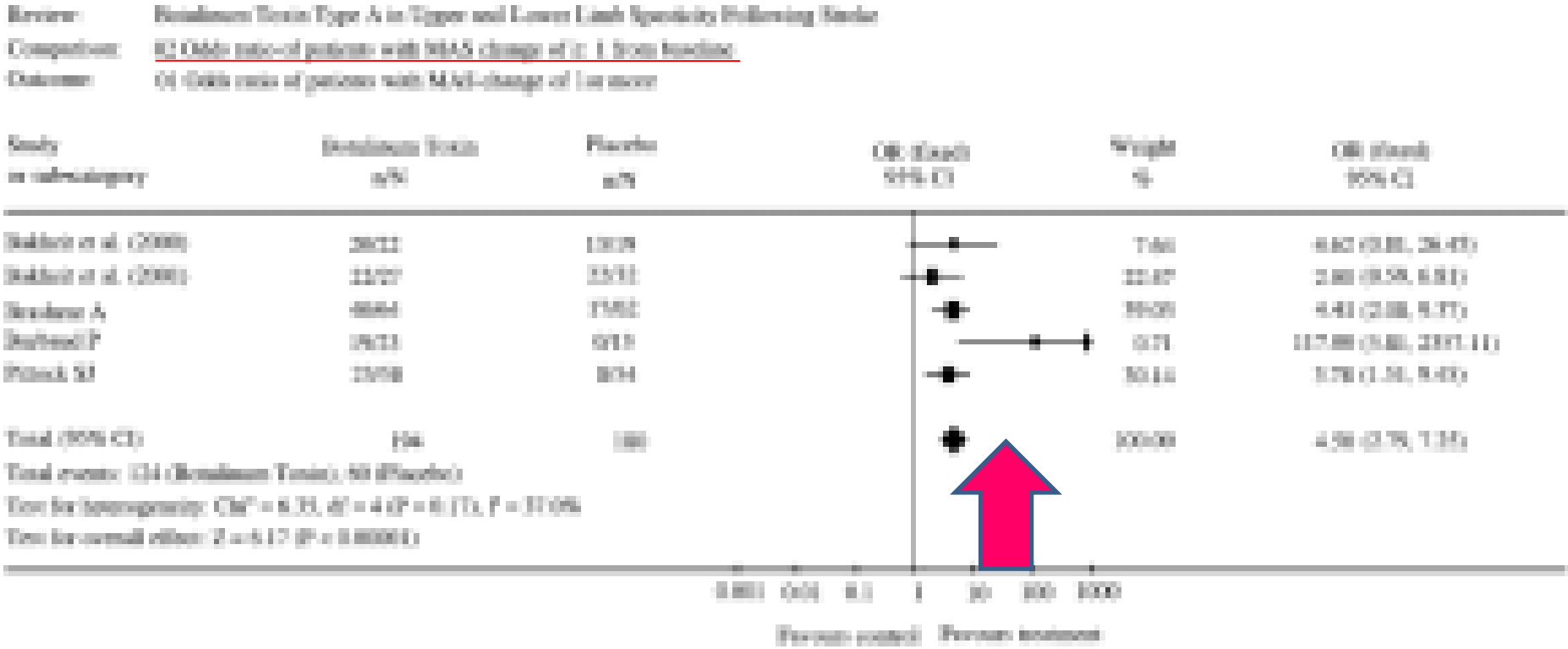


Fig. 2. Odds ratio showing change in MAS score of >1 point after BoNT-A treatment at 4–6 weeks follow-up

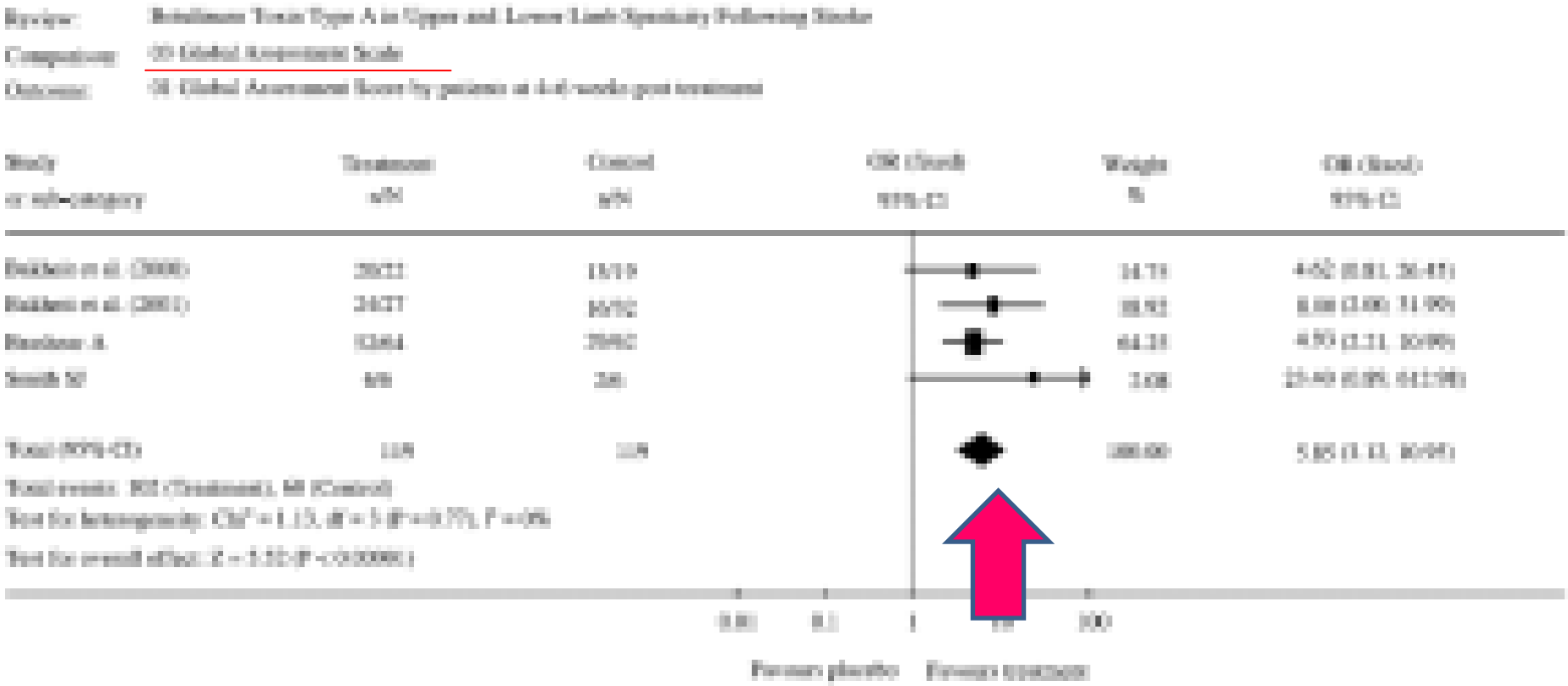


Fig. 3. Odds ratio showing change in GAS score after BoNT-A treatment at 4–6 weeks follow up

Review: Botulinum Toxin Type A in Upper and Lower Limb Spasticity Following Stroke

Comparison: 04 Adverse events

Outcome: 01 Adverse events reported, general

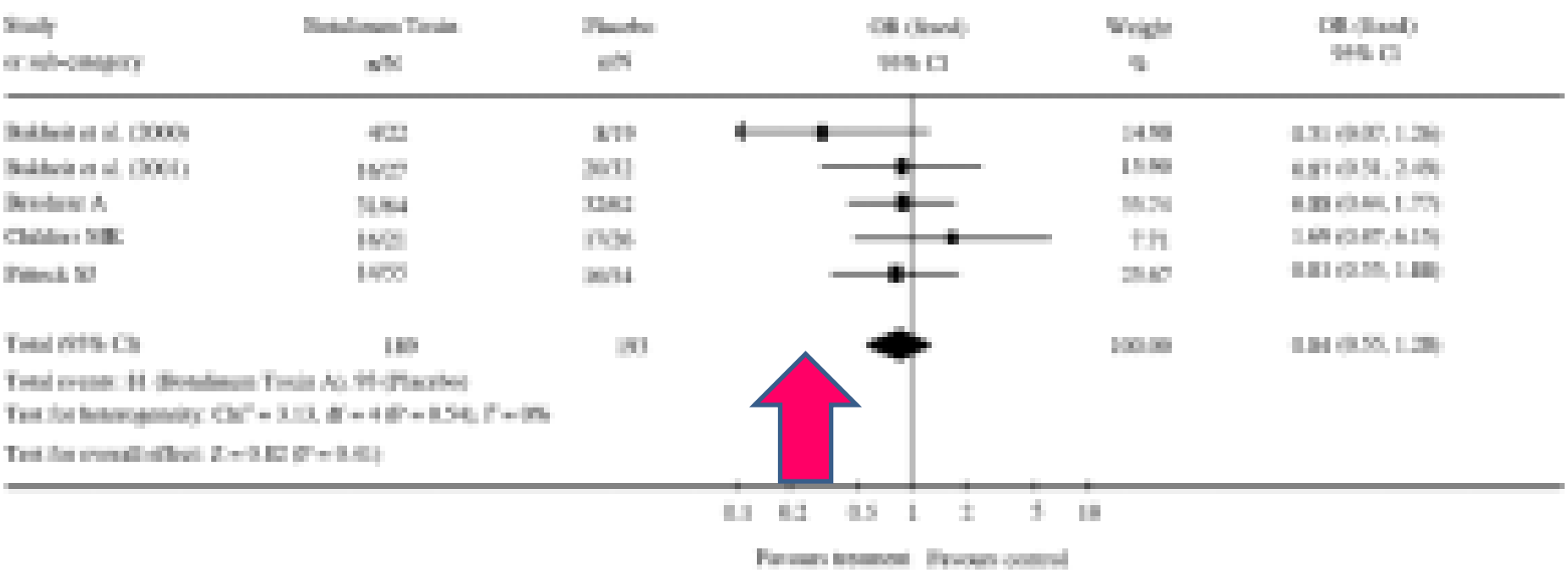


Fig. 4. Odds ratio of having an adverse event with BoNT-A treatment

Reviewers' conclusions

- Implications for practice:
- Based on the Class I studies, BoNTA effectively decreases muscle tone in UL and LL spasticity following stroke, improves QOL and is safe.

- Implications for research:
- Translation to a clinically meaningful improvement in functional disability would be a more desirable measure.
- Hence, refinement of a standardized measure in functional disability would be ideally included.

Botulinum Toxin for post-stroke spastic hypertonia: a review of its efficacy and application in clinical practice

Gerard E Francisco

Ann Acad Med Singapore 2007; 36: 22-30

Objective

- This paper will review the evidence supporting the efficacy of BTX for spastic hypertonia and discuss current clinical practice.

Method

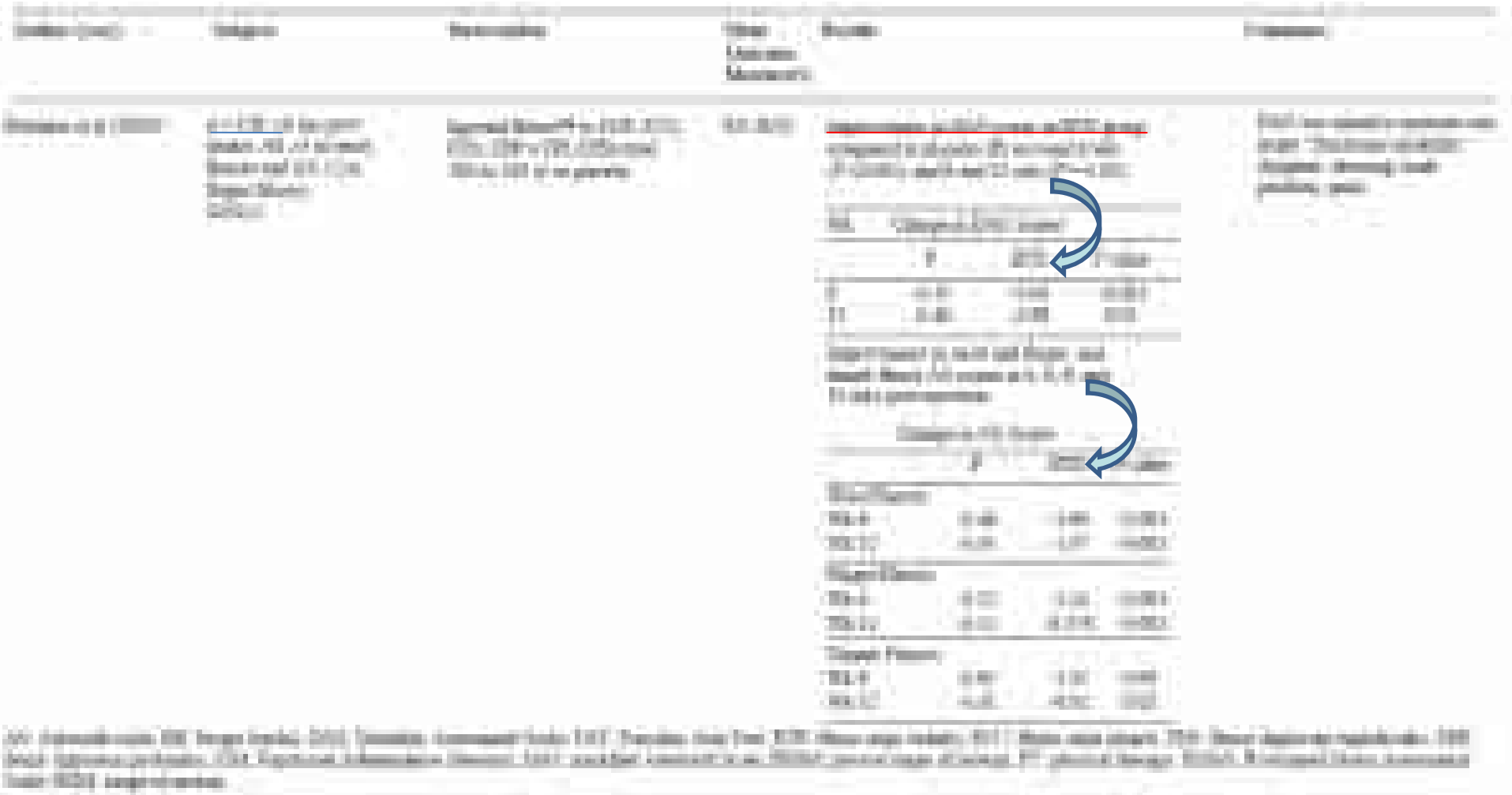
- An online literature search was performed using Medline and PubMed.
- Search terms used were “stroke”, “cerebrovascular accident”, “spasticity”, and “botulinum toxins”.
- From a total of 140 articles, only 8 RCTs were found and included in this review.

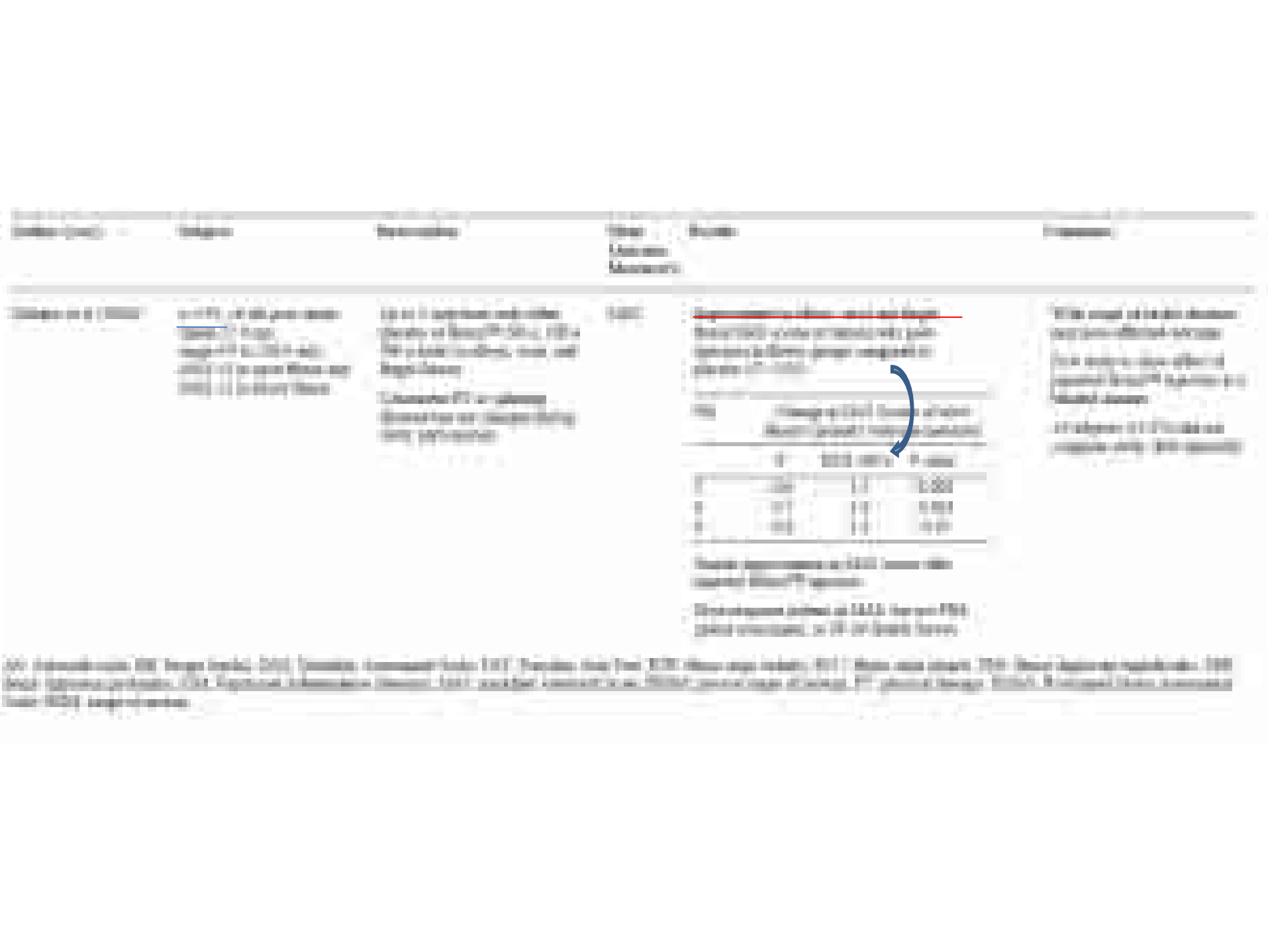
Author (year)	Subjects	Interventions	Other Outcomes Measured	Results	Comments
Group[a]:					
Chignon A-L (2006)	n = 45 (19 pts controlled-release n = 11 n/a range 22-57 yrs) swallow-ver most likely...	Completed 1 video lesson of about 8 min in length (duration varied) n=466; 8 (0.7) = n placebo Time = Threshold Variable = 1% n-rate Scale = 0% n-rate	none	Improvement in efficacy and end of the 1-hr n-rate (1-hr scale data (SD) NR (1 group at 1, 3 and 5 wk and 24 mos completed a placebo (P = 0.45).	For questions 5 different methods placebo and treated groups no cross-over and 1 withdrawal between (ITT). PSA caregiver. Numbers = Nausea and pain associated with Rhythm had (data not

TD	1-hr[1] (Mean Minute Basis)		1-hr[1] (Mean Hour Basis)	
	M	SD[2]	M	SD[2]
1	0.1	0.4	0.1	0.4
2	0.2	0.4	0.1	0.3
3	0.3	0.5	0	0.0

[1] = Measured by age residence cross by wk. 0 post-operative

(AV: Antivenin costs (NS Hunger Inertia; [101] Questions Assessment Index [107] Particles Acid Test [178] Mean wage median); [61] Mean wage (mean [79]); Dental Application Applicable; [39] Mean Difference participants; [34] Significant Administration Measure; [107] associated Assessment to see [95%CI] percent wages of average; [1] percent Average [95%CI]; B recognized Index Assessment Scale [82]); weight members.





Author (year)	Subjects	Intervention	Other Outcome Measures	Results	Comments
Dysport®					
[illegible]	n = [illegible] [illegible]	[illegible] Dysport® [illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Odds Ratio		[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

Author (year)	Subjects	Intervention	Main Outcome Measure(s)	Results	Comments
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

Author (year)	Subjects	Interventions	Other Outcomes Measured	Results	Comments
[illegible] et al. [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

Summary of clinical effects

- Significant efficacy in decreasing spastic hypertonia of UL and LL muscles
- However, the effect on function has not been systemically investigated
- Comparison of the safety and efficacy of Botox and Dysport has not been performed.

Table 2. Factors that Affect Dose Selection of BTX

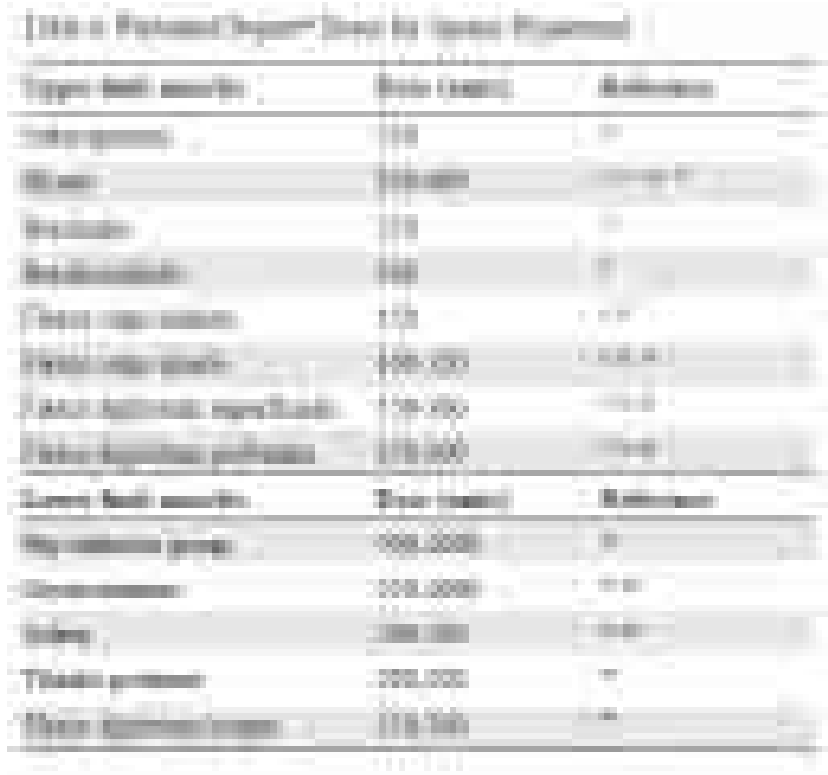
Patient-related factors:
Spastic hypertonia severity
Muscle and limb involvement
Spastic hypertonia duration
Age and body mass
Outcome of prior BTX treatment
Clinician-related factors:
Experience, knowledge and expertise
Other factors:
Cost
Availability of adjunctive therapy

BTX: Botulinum toxin

Table 3 and 4 (dosing)

Botox

Dysport



Dosing Frequency and Repeated Injections

- It is common clinical practice to inject BTX not more frequently than every 3 months
- The use of BTX in cervical dystonia: high initial doses, frequent injection, and “booster” injections were identified as factors contributing to the development of antibodies
- no published prospective study yet investigating the occurrence of antibodies specifically in spastic hypertonia.

Why Haven’t We Shown Functional Improvement?

- may be due to limitations in study design and methods.
- fundamental problem is the widespread use of AS or MAS as primary outcome measures.
- However, this oversimplifies function, which also depends on muscle strength, coordination, endurance and muscle agonist-antagonist action.

- valid functional outcome measures were seldom used in published studies. Most have utilized global scales, such as the FIM, which may not be sensitive to functional changes.
- Poor patient selection may also have affected the study outcomes.

Summary of the paper

- BTX has been successfully shown to be an effective therapy for post-stroke patients
- published literature hasn’t demonstrated its impact on functional recovery.
- Future studies should pay particular attention to study design, including the selection of appropriate subjects and outcome measures.

Post Stroke Hemiplegia: lower limb benefit from botulinum toxin (Review)

A.P.Yelnik *, I.V. Bonan

March 2003

Objective

- To clarify the conditions governing the use of botulinum toxin (BTX) for post-stroke lower limb spastic disorders: indications, choice of muscles, doses, and duration of efficacy.

Method and Results

Method

- Review of the international literature using the Medline and the Reedoc data banks.

Results

- 7 controlled studies were reviewed
- The usefulness of BTX for the treatment of equinovarus has been demonstrated.
- The main muscles to be treated are the *soleus, gastrocnemius and TP*
- The benefit may last for more than 6 months.

Conclusion of the paper

- Botulinum toxin has a place together with other local treatments for post-stroke spasticity
- but a precise guide to its use, especially its dosage, and it’s effectiveness compared to that of other treatments, need further study.

Safety issues of Botulinum toxin

Pooled Analysis of the Safety of Botulinum Toxin Type A in the Treatment of Poststroke Spasticity

Catherine C. Turkel, PharmD, MBA, Beta Bowen, MS, Jingyu Liu, PhD, Mitchell F. Brin, MD

Arch Phys Med Rehabil Vol 87, June 2006

Objective and design

- Objective: To examine the safety of botulinum toxin type A
- Design: Analysis of pooled data of 9 double-blind, placebo controlled studies of patients with spasticity after stroke.

Participants & Intervention

- Participants: A total of 482 patients with upper-limb spasticity and 310 with lower-limb spasticity (overall mean age: 58y; 60% men).
- Intervention: Treatment with BTX-A (n534; 1–3 treatments; mean dose, 231U) or placebo (n258).
- Outcome Measure: Adverse events

Table 2 | Wing Design, Occupancy, Maritime Warning, and Decision Log Records for the Consolidated Fundamental Passenger-Inverted Study at Arbor Promenade Assembly Entrance

Design	Wing Design Occupancy	Learning Log	Maritime Location Lecture Arbor Environment	Promenade Entrance Law	Maritime
Voyage Vision Number:					
Case Improvement: 1 oz [1870] to Harbor Environment	2,0427	14% (1,2pc) 1947	Pharmacy Legacy Lecture [2022]: case economy [2%] to Decision Measuring Knowledge [2021] and Continental [2nd] Lecture Harbor, Legislation Guideline [1951] and the Policy Lifeboat Hospital [1954]	[1]	10% [8]
Case Improvement: 1 oz [1870] to Harbor Environment	[1,0]	19% [2,0]; 1997	Student Instruction to Objective Associate Investment to Investment to Laboratory	[8]	10% [8]
Oil to 1 Improvement: 1 oz [1870] to Harbor Environment	[1,0]	1950 1997	1-1 Insurance Improvement and Knowledge to Investment to Laboratory	[2]	10% [1]
Case Improvement: 1 oz [1870] to Harbor Environment	[2,0]	1% [1,0]; 1950	Marriage Insurance [8]; [2,0]%; Insurance Lecture Investment [1,0]%; and Vitamins [1,0] Lecture	[1]	[1,0]; 10%
Case [1,0] Improvement: 1 oz [1870] to Harbor Environment	[1,0,0]%	[1,0]; 1950; 1997	Marriage Insurance [8]; [2,0]%; Insurance Lecture [1,0]%; Medicine Investment [1,0]%; and [2%]; Science Improvement Investment [1,0]; [1,0]; and Laboratory [1,0] 1997	[1]; Audit within Case; and Improvement	[1,0]; 10%
Case Improvement: 1 oz [1870] Density to Improvement	[2,0,0]	1% [1,0]; 1950	Science to Lecture	[1]	10% [1]
Income Profile Density:					
Case Improvement: 1 oz [1870] to Harbor Environment	[1,0]%	[1,0]; [2,0]	Psychology Density [2%–2,0,0]; Lecture [1,0]; Science Environment Analysis [8]; [1,0] to Investment Lecture [1,0]; [1,0]	[1]	10% [2]
Case [1,0] Improvement: 1 oz [1870] to Harbor Environment	[1,0,0]	1% [1,0]; [1,0] Density Case Work Improvement to [1,0] [1,0] Density Case Work Improvement	Chemical Lecture [8]; [1,0]; Investment Lecture [1,0]; [1,0]; and Investment to Laboratory [1,0]; [1,0] to Investment Laboratory [8]; [8]; [1,0]	[2]; Audit within Case; and Improvement	10% [1,0]
Case Improvement: 1 oz [1870] to Harbor Environment	[1,0,0]	[1,0]; [1,0] Density Case Work Improvement to [1,0] [1,0] Density Case Work Improvement	Chemical Lecture [8]; [1,0]; [1,0] Investment to Investment Lecture [1,0]; [1,0] to Investment Laboratory [8]; [8]; [1,0]	[1]	10% [8]

[1] Plan Lecture Density Improvement: 1 oz [1870] to Harbor Environment; Income Improvement to Laboratory; and to Legislation Promotion.

[2] Statement to Case Lecture Density Case Improvement: 1 oz [1870] to Harbor Environment; Income Improvement to Laboratory; and to Legislation Promotion.

[3] Promotion Lecture and Legislation Density: [1,0] Case [1,0] Density; [1,0] Case Lecture Density Case Improvement Lecture; [1,0] Density [8]; [1,0] [1,0] Density Case; [1,0]; Density; [1,0]

Table 2: Patient Demographics

Characteristic	BTK-A (n = 648)	Placebo (n = 324)	p
Age, [u]			.111
Mean (± SD)	67.8 (11.8) [a]	68.2 (12.4)	
Range	[b]–89	18–87	
Age group, n (%)			
18–[u] < 40	46 (6.4)	22 (6.8)	
40–[u] < 65	333 (48.8)	168 (48.8)	
65–[u] < 75	177 (27.3)	87 (26.9)	
≥ 75	92 (14.2)	39 (12.0)	
Sex, n (%)			.007
Male	339 (49.4) [c]	161 (50.0)	
Female	348 (50.6) [c]	161 (50.0)	
Race, n (%)			.216
White	462 (68.5) [c]	211 (65.4)	
Black	45 (6.4)	20 (7.0)	
Asian	117 (17.3) [c]	57 (17.7)	
Hispanic	9 (1.3)	6 (1.9)	
Other	11 (1.5)	2 (0.6)	

Abbreviations: SD, standard deviation.

Table 3: Most Frequent Treatment-Emergent Adverse Events (% of patients)

Adverse Event	BTK-A (%) (n = 324)	Placebo (%) (n = 324)	p
Cough[a]			
Dyspnea	2.0	5.6	.004
Respiratory infection	4.2	7.0	.052
Rhinitis	4.7	5.1	.847
Arm pain	4.3	3.5	.750
Peripheral edema	4.2	3.4	.894
Consolidation	4.1	3.0	.750
Pain	3.0	4.7	.394
Back pain	2.5	5.3	.054
Hypertension	2.8	4.0	.391
Interstitial lung pain	3.4	3.4	.647
Unplanned surgery			
(per investigator's opinion)[b]			
Hypertrophy	1.8	1.8	.721
Peripheral edema	2.8	0.8	.403
Injection site pain	2.2	4.7	.043
Arm pain	1.7	1.2	.671
Nausea	1.5	0.0	.062

[a]Cough included chronic occurring or more than 4% of patients in either group.
[b]Data for treatment-induced pain the opinion of the investigator which investigator's adverse events included those occurring in more than 1.8% of patients in the BTK-A group. Adverse events ordered according to occurrence in the BTK-A group.

Conclusion of the paper

- No unexpected safety issues with BTX-A were identified in the present analysis.
- Data support the utility of BTX-A as part of a comprehensive, multimodal treatment programme for focal post-stroke spasticity.

Distal LL equinovarus spasticity: any alternative treatment

Comparison of botulinum toxin injection and neurotomy in patients with distal lower limb spasticity

B. Rousseaux[a], N. Bussel[b], W. Darbois[a], O. Hentsch[a] and S. Brin[a]

[a]Service de Rééducation Neurologique, Hôpital de Lambersart, 41 Rue Jules Guesde, and [b]Service de Neurochirurgie, Hôpital Salengro, CHRU de Lille, France

Keywords:
botulinum toxin, neurotomy, spasticity, ataxia

Received 17 November 1999
Accepted 8 February 2000

Background and purpose: We compared the efficacy of botulinum toxin type-A (BTX) and tibial nerve neurotomy (TNN) in an open-label study of 14 non-stroke hemiplegic patients with distal lower limb deformities. **Methods:** The class of BT was BAT I (Botox). TNN was performed with a 4–12 month delay on the worse hemiplegic of the (BTX) series. Selective or by-interval ward control consisting of the above different (spasm, cramp and clawing) pain. Patients were assessed following each treatment (in spasticity), stride velocity, range of dorsiflexion, balance, gait and the Rivermead Motor Assessment. **Results:** TNN (NL, NA and V1) resulted in a more significant effect than BTX (FFT, MT and WC) on most of the measures, whilst physical therapy, range of movement or dorsiflexion and walking (not posture in upright position). Functional Ambulation Categories (functional), RMA, gait velocity, comfortable cadence, objective benefit and use of walking aids. Patients treated by tibial neurotomy or fibro digestion longer spasticity (also assessment of subjective severity disorders in the plantar side) over a period of 4–6 weeks. **Conclusions:** In conclusion, TNN is more effective than BTX in most of the functional parameters. The interest of BTX lies in the potentiation or recovery of the effects of a decrease for relieving spasticity on lower limb functions.

Table 1 Effects of [illegible] on [illegible]

		[illegible]				[illegible]				
		Day 1	Day 17	Week 1	Week 3	Day 1	Week 1	Week 3	Week 5	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

Figure 1 [illegible]

Table 4 [illegible]

		Reinforcement learning parameters				Choice parameters				
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]
[illegible]
[illegible]

Adverse effects

Botulinum toxin

- transient pain

Tibial neurotomy

- Sensory disorders resulted from resection of the motor branches controlling the TP and/or the flexor digitorum longus

Study conclusion

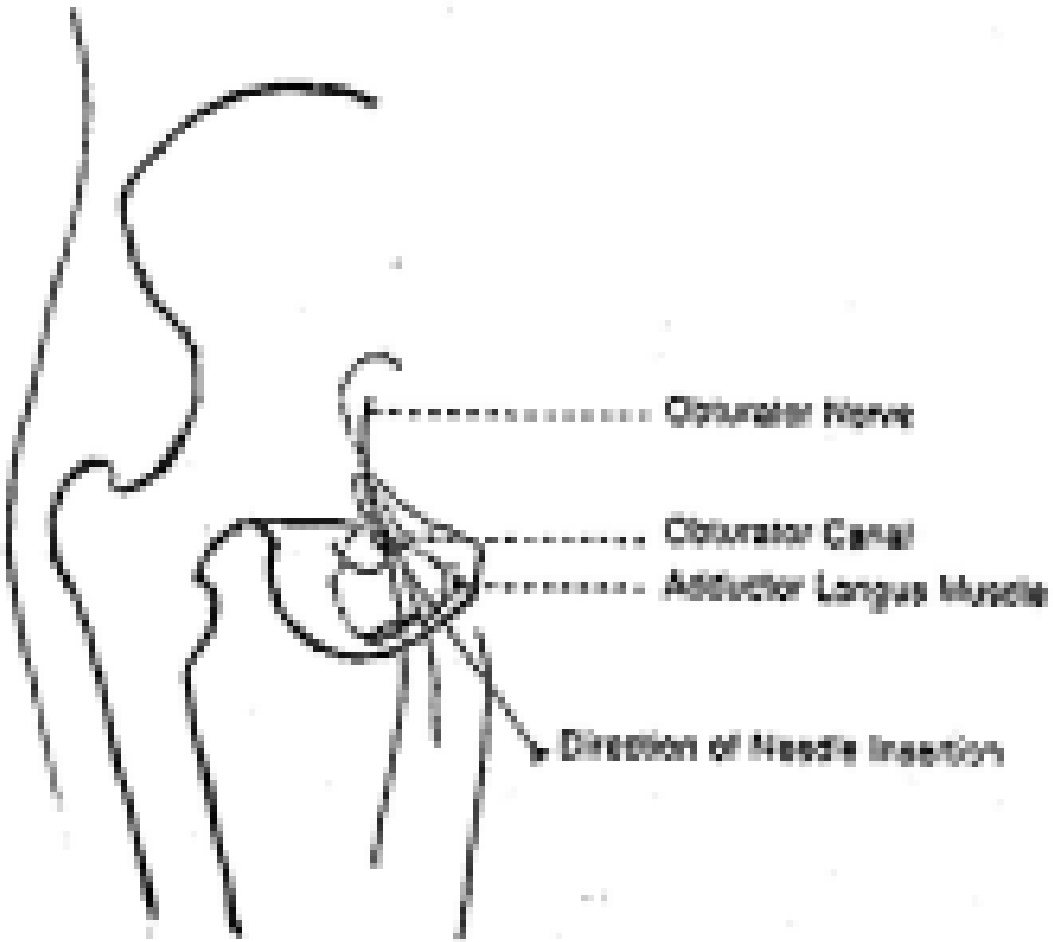
• TNN is much ***more effective*** than BTI in reducing the equinovarus deformity and improving lower limb function in patients with stroke.

• However, the difference does not discredit BTI use

Bring Home Messages

- Equinovarus spastic deformity is among one of the commonest UMN syndrome in LL
- Botulinum toxin could effectively and safely tackle distal limb spasticity
- Whereas proximal (Obturator) phenol neurolysis is an effective and safe adjuvant therapy in the presence of adductor spasticity
- For EBM, large RCTs of Botulinum therapy with proper functional outcome

Thank you



...he Intraadductor approach to the obturator nerve block. ...m depicts the block needle direction and alignment with ...ator canal. Note the two branches of the obturator nerve, ...e obturator canal, immediately separate at its exit.