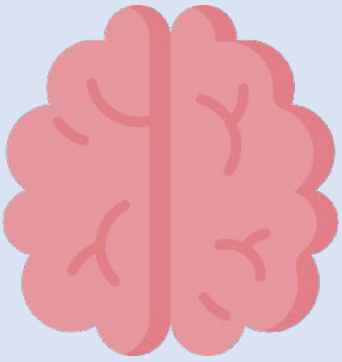

Revised & Approved

Abdullah Alsubaihi
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Pharmacology 439

MED439

Neuropsychiatry Block

Pharmacology Team 439

Helpful video

Color index:

Main Text

Important

Dr's Notes

Female Slides

Male Slides

Extra

Antiepileptic drugs

We highly recommend studying [pathophysiology of epilepsy] before this lecture

Objectives:

1- Describe types of epilepsy
2- List the antiepileptic drugs.
3- Describe briefly the mechanism of action of antiepileptic drugs.
4- Enumerate the clinical uses of each drug.
5- Describe the adverse effects of each antiepileptic drug & treatment of status epilepticus.
6- Classify antiepileptic drugs according to the type of epilepsy treated and generation introduced
7-Expand on pharmacokinetic and dynamic patterns of first and second generation antiepileptic drugs.

Editing file

Epilepsy

Epilepsy is a chronic medical condition characterized by 2 or more unprovoked seizures (within 6-12 months). It is a syndrome.

The Difference Between:

1) Epilepsy & Seizures

1

Epilepsy

A group of related sign and symptoms characterized by a tendency for recurrent seizures
Two or more unprovoked (no trigger) seizures within 6-12 months

2

Seizures

Brief, sudden, uncontrolled abnormal electrical activity in the brain, are a symptom of epilepsy. A Single episode

2) Syndrome & Disease

1

Syndrome

A set of medical signs and symptoms that occur together and suggest the presence of a certain disease
(idiopathic & combination of symptoms).

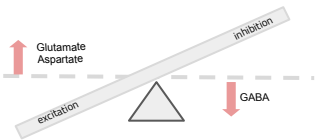
2

Disease

The actual diagnosed impairment of health or a condition of abnormal functioning (non- idiopathic & it's a combination of symptoms) distinguished cause, symptoms and treatment

★ Epilepsy results from increased level of **Glutamate** and decreased level of **GABA**. (important for MCQs)

Normal CNS function



Abnormal excitation

Treatment

Etiology of Epilepsy

- Congenital defects, head injuries, trauma, hypoxia
- Infection (bacteria or virus) e.g. meningitis, brain abscess, viral encephalitis.
- Concussion, depressed skull, fractures.
- Brain tumors (including tuberculoma), vascular occlusion, stroke

- Drug withdrawal, e.g. CNS depressants, alcohol or drug abuse or drug overdose, e.g. penicillin.
- A poison, like lead
- Fever in children (febrile convulsion). (Not harmful)
- Hypoglycemia (insulin shock)
- PKU[1] (Phenylketonuria) (Phenylalanine $\xrightarrow{\text{Phenylalanine hydroxylase}}$ Tyrosine)
- Photo epilepsy (usually due to flashing lights in video games)

1) An inherited disorder in which there's an error in the metabolism of phenylalanine caused by the deficiency of the enzyme phenylalanine hydroxylase → the phenylalanine increases in the blood.

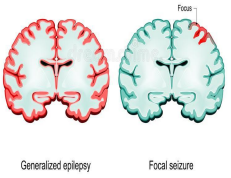
Triggers of Epilepsy

Fatigue | **Sleep deprivation** | **Stress** | **Poor nutrition** | **Alcohol**

Classifications of Epilepsy

1

Primary Generalized:
Both hemispheres + loss of consciousness.



Partial (focal):
Arise in one cerebral hemisphere

2

A) **Tonic-clonic:** Stiffness followed by violent contractions & relaxation (1-2 minute).

B) **Tonic**: Muscle stiffness

C) **Clonic**: Spasms of contraction & relaxation

D) **Atonic (loss of tone)**: Patient's legs give under him & drop down

E) **Myoclonic**: Jerking movement of the body

F) **Absence(Petit mal):**Brief loss of consciousness with minor muscle twitches. Eye blinking (no fall down).

G) **Status epilepticus** (Dangerous): Recurring/prolonged tonic-clonic seizure (30 min or more)

A) **Simple**:
consciousness is retained

B) **Complex**:
Altered consciousness

C) **Partial with secondary generalization:** Begins as partial (simple or complex) and progress into Generalized seizure (tonic clonic)

General rules for treatment of Epilepsy

- Epilepsy is usually controlled but not cured with medication.
- Up to 80% of patients can expect partial or complete control of seizures with appropriate treatment.
- Antiepileptic drugs are indicated when there is two or more seizures occurred in short interval (6 m -1y)
- An initial therapeutic aim is to use only one drug (monotherapy). To avoid ADRs
- Drugs are usually administered orally
- Monitoring plasma drug level is useful
- Triggering factors can affect seizure control by drugs.
- Sudden withdrawal of drugs should be avoided. Worsens the seizure and higher chances of reoccurrence

Withdrawal considered:

1. Seizure-free period of 2-5 years or longer
   Generally, the longer the remission the lower the chances of recurrence
2. Normal IQ Intelligence Questions
3. Normal EEG prior to withdrawal
4. No juvenile myoclonic epilepsy (muscle jerks, generalized tonic-clonic seizures. Often happen when people first awaken in the morning)

- **Relapse rate when antiepileptics are withdrawn is 20-40%**

Treatment of epilepsy

Drugs

Our concern in this lecture

Click here for more

Vagal nerve stimulation

Surgery

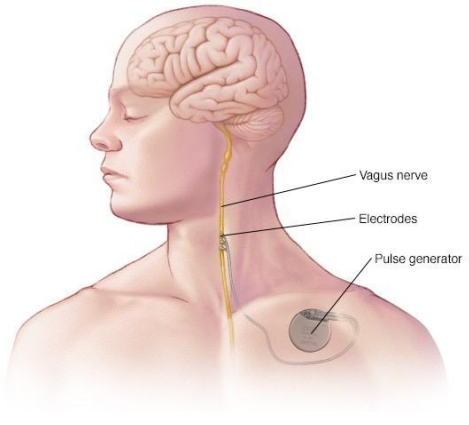
If the affected part of the brain is insignificant, surgical removal is an option

Increased dietary fat consumption & decreased carbs → lipolysis instead of glycolysis → protective against unpredictable excessive electrical activity

Ketogenic diet

Vagal nerve stimulation

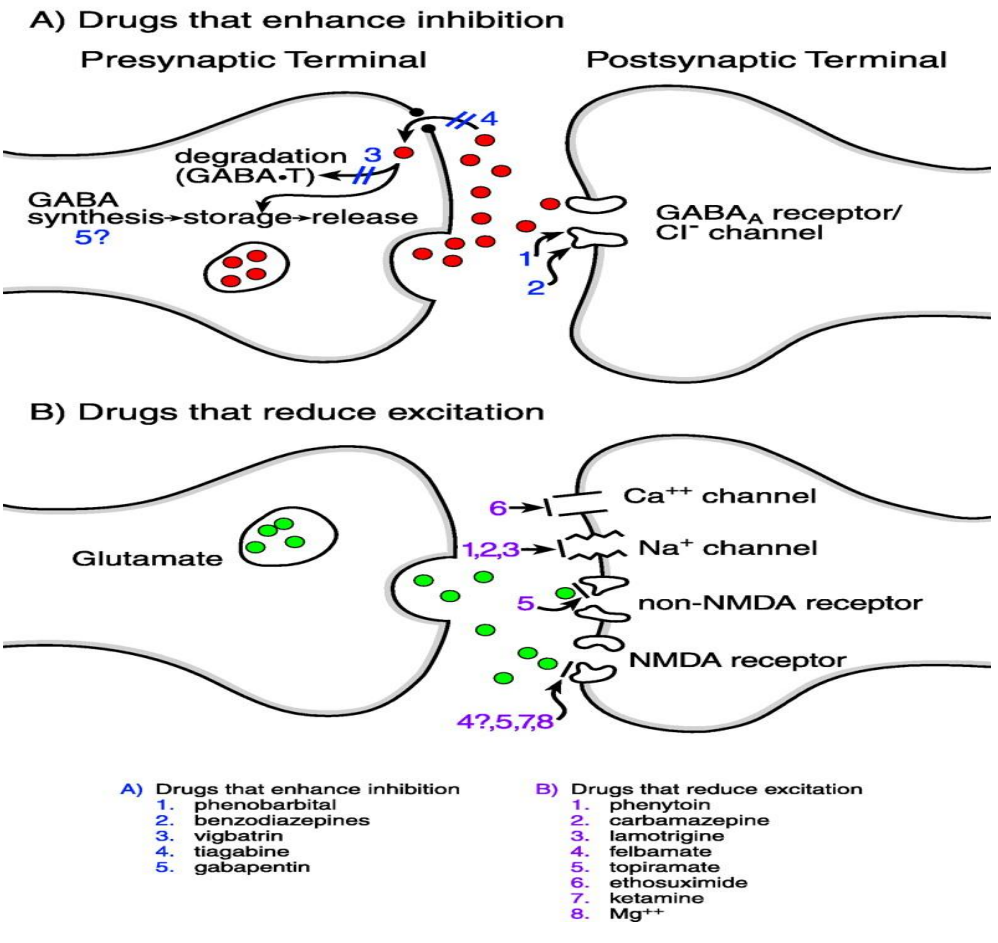
- It is an alternative for patients who have been refractory to multiple drugs
- Who are sensitive to many adverse effects of antiepileptic drugs
- It is expensive procedure, use it as last option



Mechanism of anti-epileptic drugs

They inhibit depolarization of neuron by:

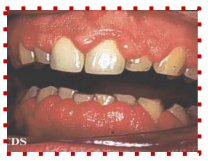
- Increase outward positive current (K^+)
- Blockage of voltage-gated positive current (Na^+, Ca^{2+})
- Enhancement of inhibitory neurotransmission (GABA)
- Inhibition of excitatory neurotransmission (Glutamate)



1st Generation		2nd Generation	
1st	**Phenytoin**	2nd	**Lamotrigine**
1st	**Carbamazepine**	2nd	**Topiramate**
1st	**Valproate**	2nd	Levetiracetam
1st	**Ethosuximide**	2nd	Gabapentin
1st	Phenobarbital and primidone	2nd	Felbamate
1st	Benzodiazepines e.g. clonazepam, lorazepam and diazepam	2nd	Zonisamide
		2nd	Pregabalin

Both gens have the same efficacy, but second gen is safer and more suitable for some people e.g. pregnant

1st Generation

Drug	Phenytoin	Fosphenytoin
M.O.A	• Blockade of Na^+ & Ca^{2+} influx into neuronal axon. • Inhibit the release of excitatory transmitters e.g. glutamate and aspartate • Potentiate the action of GABA gamma-Aminobutyric acid (GABA): inhibitory neurotransmitter, Its principal role is reducing neuronal excitability throughout the nervous system.	
P.k	• Given orally, well absorbed from GIT • Also available I.V and I.M (**fosphenytoin**) • **Enzyme inducer.**; a type of drugs that increase the metabolic activity of the enzyme. They often cause drug-drug interactions → low bioavailability hence should be administered alone • Metabolized by the liver to inactive metabolites • T½ approx. 20 hr. • Excreted in urine.	• Parenteral form of phenytoin (IV & IM) • **A Prodrug** • rapidly converted to phenytoin in the body. Advantage over **phenytoin**: • Lower local tissue and cardiac toxicity • Less pain phlebitis (inflammation of veins) at injection site.
Uses	• Partial and generalized tonic-clonic seizures • **Not in absence seizure.** • In status epilepticus, given IV.	
ADRs	• Nausea or vomiting • headache, vertigo, ataxia, diplopia , nystagmus • Sedation • Gum (gingival) hyperplasia[1] (pic on the side) • **Hirsutism** (excessive hair growth, Contraindicated in women) • Acne • Folic acid deficiency (Megaloblastic anemia) • Vit D deficiency (Osteomalacia) • Teratogenic effect (Contraindicated in pregnancy)[2]	
Extra: **Phenytoin ADRs (mnemonic)** **P**ain **H**irsutism **E**nlarged Gum **N**ystagmus **Y**ellow- brown pigmentation **T**eratogenic **O**steomalacia **I**nterfere with folic acid absorption **N**europathy (peripheral)	(1): blockade of calcium influx → decreased folic acid uptake → decreased collagenase which are enzymes that assist in destroying extracellular structures	(2) generally **all antiepileptics are contraindicated in pregnancy** and are very harmful in such cases but two drugs are "safer" to use which are Lamotrigine and Levetiracetam

1st Generation (cont.)

Drug	Carbamazepine (CBZ)
M.O.A Same as before	• Blockade of Na+ & Ca + + influx into neuronal axon • Inhibit the release of excitatory transmitters e.g. glutamate and aspartate • Potentiate the action of GABA gamma-Aminobutyric acid (GABA): inhibitory neurotransmitter,Its principal role is reducing neuronal excitability throughout the nervous system.
P.k	• Available as capsules & Syrup only orally • Well absorbed • **Strong enzyme inducer including its own metabolism** • Metabolized by the liver to active & inactive metabolites • Half life 18-35 hr • Excreted in urine
Uses	★ **Drug of choice in partial seizures.** • Tonic-clonic seizures (1ry & 2ry generalized) but Not in absence seizures • **Other uses:** - Bipolar depression mood swings - Trigeminal neuralgia inflammation of CN5 that results in severe pain sensations in the face - Use with patients who have bipolar depression & epilepsy
ADRs	• GIT upset • Hypersensitivity reactions • Drowsiness , ataxia, headache & diplopia • **Hyponatremia & water intoxication** (hyperosmotic urine) • Teratogenicity; contraindicated in pregnancy

Drug	Ethosuximide (ETSM)
M.O.A	• **Inhibits T- type Ca^{2+} channels in thalamo-cortical neurons** (post synaptic)
P.k	• Absorption is complete • Syrup & capsule forms • Not bound to plasma proteins or tissues, high volume of distribution • Metabolized in liver • Half life 52-56 hr • 10-20% of a dose is excreted unchanged the urine ★ It's not an enzyme inducer nor bound to plasma proteins → can be used with other antiepileptics (IMPORTANT)
Uses	• **Absence seizures**
ADRs	• Gastric distress: nausea, vomiting • Drowsiness, fatigue , hiccups, headaches

1st Generation (cont.)

Drug	**Sodium Valproate** (VPA) aka. Valproic acid **(Broad spectrum antiepileptic)**
M.O.A	• Blocks activated Na+ channels. • Enhances GABA synthesis & reduces degradation • Suppress glutamate action. • Blocks T-type Ca^{2+} channels
P.k	• Available as capsules, Syrup , I.V • Metabolized by the liver (inactive) • **Enzyme inhibitor** → increased bioavailability → potential toxicity • Half life 12-16 hr • Excreted in urine

Uses	**It is effective for all forms of epilepsy**
	• Generalized tonic-clonic seizures (1ry or 2ry)
	• Absence seizures
	• Complex partial seizures
	• Myoclonic
	• Atonic
	• photosensitive epilepsy
	• **Other uses:**
	  ○ Bipolar disorder and mania (or Carbamazepine)
	  ○ Prophylaxis of migraine
	  ○ Lennox-Gastaut syndrome: a childhood epileptic encephalopathy which is usually caused by early brain injury or congenital malformations. Patients with LGS can have different kinds of seizures.

ADRs Extra: Valproate ADRs (mnemonic) **V**omiting **A**ppetite ↑ **L**iver toxicity **P**ancytopenia **R**egrowth of curly hair **O**edema **A**spirin contraindication **T**eratogenicity **E**nzyme inhibitor	• GI (nausea, vomiting , heart , burn) • **Weight gain (↑ appetite)** • Transient hair loss, with re-growth of curly hair • Thrombocytopenia (low platelet count) ★ **(not used with aspirin[1] or coumadin[2] "warfarin")** 1) aspirin & valproate are highly bound to plasma proteins → aspirin displaces valproate from its binding site → increase conc of valproate 2) Sodium valproate replace warfarin from protein binding site → Risk of bleeding • Transient increase in liver enzymes & hepatotoxicity • Teratogenicity **(neural tube defect)**

To wrap things up in first generation, find the appropriate drug

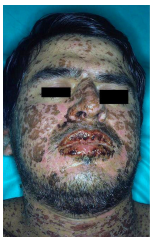
M	B	L	C	H	Y	G	A	P	K	A	G	F
G	B	N	A	L	G	G	Q	J	L	F	X	R
E	N	I	R	M	Z	H	X	R	Y	C	Z	Q
D	H	O	B	C	S	T	H	T	U	N	O	L
I	J	T	A	P	H	E	N	Y	T	O	I	N
M	M	Y	M	E	T	J	J	M	M	B	M	P
I	X	N	A	O	T	N	J	H	N	M	L	C
X	S	E	Z	J	L	A	O	S	G	H	V	L
U	M	H	E	Q	M	O	R	G	A	P	J	Z
S	K	P	P	R	C	P	X	O	H	A	S	F
O	L	S	I	V	S	Q	U	P	P	O	M	S
H	F	O	N	H	L	F	K	W	O	L	A	R
T	G	F	E	U	J	A	Z	F	R	J	A	F
E	T	H	O	H	J	K	Z	V	R	U	I	V

- Hints:
  1. Inhibits low voltage calcium channels+Used for absence seizures
  2. Drug of choice in partial seizures+Can cause hyponatremia
  3. A prodrug+Contraindicated in women
  4. Enzyme inducer
  5. Enzyme inhibitor+Reduces degradation of GABA

- Check slide 13 for answers

2nd Generation

Drug	Topiramate (Topamax)
M.O.A	• Blocks **Na+** channels (membrane stabilization) • Potentiates the inhibitory effect of GABA.
P.k	• Well absorbed orally (80%) • Food has no effect on absorption • T½= 18-24 hrs • **Has no effect on microsomal enzymes** • 9-17 % protein bound (minimal) increased volume of distribution • Mostly excreted unchanged in urine
Uses	• Can be used alone for partial, generalized tonic-clonic, and absence seizures. • Lennox- Gastaut syndrome (or lamotrigine, or valproate). • Individuals with bipolar disorders that have resisted other forms of treatment (Off-Label).
ADRs	• Psychological or cognitive dysfunction • **Weight loss (can be a desirable effect)** unlike Valproate • Sedation, Dizziness, Fatigue • Urolithiasis (urinary tract stones) • Paresthesias (abnormal sensation) • Teratogenicity (in animal but not in human)

Drug	Lamotrigine
M.O.A	• Blockade of Na+channels • Inhibits excitatory amino acid release (glutamate and aspartate)
P.k	• Available as oral tablets • Well absorbed from GIT • T½ approx. 24 hr • Metabolized primarily by glucuronidation. • **Does not induce or inhibit C.P-450 isozymes** can be used as add-on therapy
Uses	• As add-on therapy or as monotherapy in partial seizures. • Lennox-Gastaut syndrome (or Topiramate, or valproate) • Safe for pregnant
ADRs	• Influenza-like symptoms • Skin rashes (may progress to Steven–Johnson Syndrome[1]) • Somnolence (drowsiness) • Blurred vision • Diplopia • Ataxia  1) Rare but severe rash in the mucus membranes

Summary (taken from slides)

Type of seizure	Choice among drugs
Partial seizures	**Carbamazepine**, phenytoin, valproate, lamotrigine.
Generalized seizures	
Tonic-clonic (grand mal)	Valproate, carbamazepine, phenytoin, Lamotrigine
Myoclonic	Valproate, clonazepam
Absence	Valproate, **ethosuximide**, Topiramate
Atonic	Valproate
Lennox–Gastaut syndrome (LGS)	Valproate, Lamotrigine, Topiramate

★ **Enzyme Inducers?** Phenytoin, Carbamazepine
Enzyme Inhibitors? Valproate
No enzyme activity? Ethosuximide, Topiramate, Lamotrigine
What causes weight gain/loss? Gain: Valproate, Loss: Topiramate
What blocks T-type Ca^{2+} channels? Ethosuximide, Valproate

Drugs Used for Treatment of Status Epilepticus (IV)

- Most seizures last from few seconds to few minutes. When seizures follow one another without recovery of consciousness, it is called "status epilepticus"
- It has a high mortality rate
- **Death is from cardiorespiratory failure.**

Lorazepam, Diazepam (drugs of choice) → **Phenytoin** → **Fosphenytoin** → **Phenobarbital** → **Valproate**

Pregnancy & Anti-epileptic

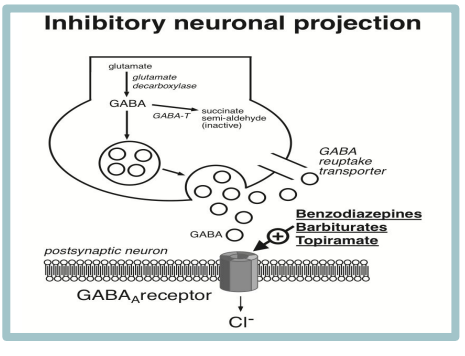
1. **Seizure is very harmful for pregnant woman** induce uterus contractions → abortion
2. **NO antiepileptic drug is safe in pregnancy. The safest drugs are (Lamotrigine & Levetiracetam)**
3. **Monotherapy usually better than drug combination** to ↓ ADRS
4. **Patient has to continue therapy**
5. **Valproate , phenytoin are contraindicated during pregnancy**

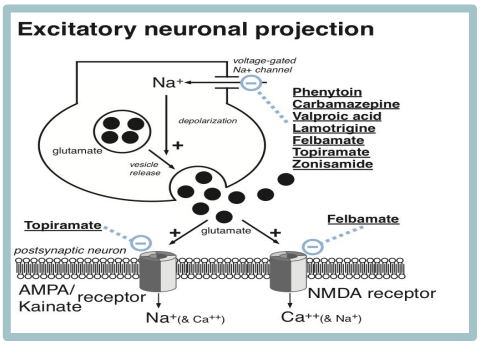
Summary (taken from slides)

- ★ Epilepsy is classified into partial or generalized according to the site of lesion
- ★ The exact mechanism of action of antiepileptics is not known
- ★ Phenytoin is mainly used for treatment of generalized tonic-clonic seizures
- ★ Carbamazepine is mainly used for treatment of partial seizures
- ★ Sodium valproate is a broad spectrum antiepileptic drug
- ★ Lamotrigine & levetiracetam are used as monotherapy or adjunctive therapy in refractory cases
- ★ Lorazepam , diazepam , phenytoin are used intravenously for treatment of status epilepticus

Extra Summary

Drug	Site of action: Sodium channel	Site of action: $GABA_A$ receptor	Site of action: Calcium channel	Site of action: Other	Main uses	Main unwanted effect(s)	Pharmacokinetics
Carbamazepine[a]	+	—	—	—	All types except absence seizures Especially focal seizures such as temporal lobe epilepsy Also trigeminal neuralgia	Sedation, ataxia, blurred vision, water retention, hypersensitivity reactions, leukopenia, liver failure (rare)	Half-life 12–18 h (longer initially) Strong induction of liver enzymes, so risk of drug interactions
Phenytoin[b]	+	—	—	—	All types except absence seizures	Ataxia, vertigo, gum hypertrophy, hirsutism, megaloblastic anaemia, fetal malformation hypersensitivity reactions	Half-life ~24 h Saturation kinetics, therefore unpredictable plasma levels Plasma monitoring often required
Valproate	+	?+	+	GABA transaminase inhibition	Most types, including absence seizures	Generally less than with other drugs Nausea, hair loss, weight gain, fetal malformations	Half-life 12–15 h
Ethosuximide[c]	—	—	+	—	Absence seizures May exacerbate tonic–clonic seizures	Nausea, anorexia, mood changes, headache	Long plasma half-life (~60 h)
Phenobarbital[d]	?+	+	—	—	All types except absence seizures	Sedation, depression	Long plasma half-life (>60 h) Strong induction of liver enzymes, so risk of drug interactions (e.g. with phenytoin)
Benzodiazepines (e.g clonazepam, clobazam, lorazepam, diazepam)	—	+	—	—	Lorazepam used intravenously to control status epilepticus	Sedation Withdrawal syndrome (see Ch. 45)	See Ch. 45
Lamotrigine	+	—	?+	Inhibits glutamate release	All types The safest drug during pregnancy	Dizziness, sedation, rashes	Plasma half-life 24–36 h
Topiramate	+	?+	?+	AMPA-receptor block	Partial and generalised tonic–clonic seizures. Lennox–Gastaut syndrome	Sedation Fewer pharmacokinetic interactions than phenytoin Fetal malformation	Plasma half-l fe ~20 h Excreted unchanged



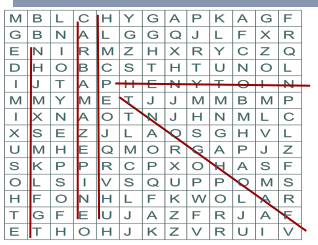


Check out these great mind maps made by Sultan Alqahtani!

MCQs

Q1: A 25-year-old woman with generalized seizures is well controlled on valproate. She indicates that she is interested in becoming pregnant in the next year. With respect to her antiseizure medication, which of the following should be considered?			
A- Leave her on her current therapy.	B- Consider switching to lamotrigine.	C- Consider adding a second antiseizure medication.	D- Decrease her valproate dose.
Q2: A 27-year-old woman has a history of epilepsy. She finds that sodium valproate is causing her to put on weight and she is keen to switch to an alternative medication. Which one of the following would be the most appropriate medication for her?			
A- Carbamazepine	B-Clonazepam	C- Topiramate	D- Phenytoin
Q3: A 16-year-old female is brought to the emergency department (ED) because of increasing drowsiness and inattentiveness. Her family tells you that she takes medication for epilepsy and may have taken an extra dose that day. On examination, she has an ataxic gait, nystagmus, and gingival hypertrophy. What medication does she take?			
A- Phenytoin	B- Carbamazepine	C- Ethosuximide	D- Valproic acid
Q4: The preferred treatment of status epilepticus is intravenous administration of			
A- Chlorpromazine	B- Diazepam	C- Succinylcholine	D- Tranylcypromine
Q5: A 32-year-old woman was brought to the emergency department because of a generalized tonic-clonic seizure. Her husband stated that his wife had been suffering from epilepsy since childhood, but the seizures were only partially controlled by medication. Which of the following pairs of neurotransmitters are thought to be most involved in seizure disorders?			
A- GABA and serotonin	B- GABA and glutamate	C- GABA and acetylcholine	D- Serotonin and glutamate
Q6: Which drug used in management of seizure disorders is most likely to elevate the plasma concentration of other drugs administered concomitantly?			
A- Carbamazepine	B- Clonazepam	C- Phenobarbital	D- Valproic acid
Q7: A child is experiencing absence seizures that interrupt his ability to pay attention during school and activities. Which of the following therapies would be most appropriate for this patient?			
A- Ethosuximide	B-Carbamazepine	C-Diazepam	D-Carbamazepine plus primidone
Q8:A 9-year-old boy is sent for neurologic evaluation because of episodes of apparent inattention. Over the past year, the child has experienced episodes during which he develops a blank look on his face and his eyes blink for 15 seconds. He immediately resumes his previous activity. Which best describes seizures in this patient?			
A- Focal	B- Tonic–clonic	C- Absence	D- Myoclonic

1	2	3	4	5	6	7	8
B	C	A	B	B	D	A	C



Answers
1-Ethosuximide.
2-Carbamazepine .
3-Fosphenytoin.
4-Phenytoin.
5-Valproate.

SAQ

Q1) 51-year-old woman with a history of type-2 diabetes and bipolar disorder is admitted for review because of low sodium (118 mmol/l). On examination her blood pressure is 139/72 mmHg, her pulse is 70 bpm, regular, and she is not in cardiac failure.

a) what drug is most likely to be responsible ?
b) List 2 ADRs

Q2) 37-year-old woman was at a routine neurology clinic visit. The woman had a long history of refractory grand mal epilepsy. She was being treated with several drugs, but with poor results. The neurologist decided to prescribe phenytoin.

a) Blockade of what type of ion channels is most likely to mediate the therapeutic efficacy of the drug in the patient's disease?
b) list 2 ADRs

Q3) young male patient suffers from a seizure disorder characterised by tonic rigidity of the extremities followed in 15–30 s of tremor progressing to massive jerking of the body. This clonic phase lasts for 1 or 2 min, leaving the patient in a stuporous state.,

a) what is the type of epilepsy the patient has ?
b) What is the most suitable drug for long term management of this patient? (2)
c) Mention the MOA of each drug

Q4) 9 years old boy was playing and suddenly he stopped and started staring and blinking and then he got back to normal.

A) What is the type of seizure that he had?
B) Which drug would be most appropriate for this patient?

Answers

A1) a) Carbamazepine; As well as being used for the management of epilepsy, carbamazepine is used in the management of bipolar disorder and is a recognised cause of hyponatremia. b) Water intoxication,Teratogenicity

A2) a) Blockade of Na^+ & Ca^{2+} influx into neuronal axon. b) Folic acid deficiency, Vit D deficiency

A3) a) This patient is suffering from generalized tonic-clonic seizures.

b) carbamazepine or phenytoin

c) Blockade of Na+ & Ca^{2+} influx into neuronal axon

A4) a) Absence seizure, b)Ethosuximide

Feedback Form

Neuropsychiatry Block

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- Aljoharah Albnyan
- Aljoud Algazlan
- Dana Naibulharam
- Fatimah Binmeather
- Feras Alqaidi
- Lama Alahmadi
- Maha Alanazi
- Manal Altwaim
- Mayasem Alhazmi
- Mona Alomiriny
- Norah Almasaad
- Noura Bamarei
- Rawan Bakader
- Rayan Jabaan
- Reem Alqahtani
- Salem Alshihri
- Sara Alharbi
- Sarah Alqahtani
- Shahad Almezel
- Shatha Aldhohair
- Teif Almutiri
- Yara Alasmari