

Fluorosis

Anaesthetic Implications

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Introduction:

- The disease fluorosis is caused by the element 'Fluorine'.
- It is the 13th most abundant element available in the earth crust & present in everything we eat, drink and breathe.
- Fluorine, a gaseous element is a halogen that is most electronegative and reactive of all elements.
- It does not occur in free form in nature.
- Molecular weight 19 & atomic number 9.

- It combines directly with most elements and indirectly with few, to form fluorides.
- It was isolated in 1886 by Noble Laureate Henri Moissan.
- As per WHO small quantities of fluoride (i.e. 0.6 ppm) ingestion is useful for bone & teeth development.
- Excess causes the disease Fluorosis.

- 1.5 mg / litre is the safe limit for FI in drinking water for human consumption.
- The acute lethal dose for 70 kg person is 2.5 to 5 gms.
- Fluorosis was earlier considered to be a problem for teeth only.
- Now it is a serious health hazard affecting not only bones & joints, but also other systems of the body.
- Today it continues to be an endemic problem all over the world.

History:

- 1771 AD Scheele identified the element.
- 1925, the term Fluorosis was coined and used by Cristian and Guatier.
- 1930 Feil mentioned flourosis in humans as an occupational disease especially in alumini speleters –
- 1932 AD Moller and Gudjonsson reported cases of skeletal fluorosis from Denmark in Cryolite Miners
- 1937 Fluorosis is detected in Andhra Pradesh
- 1952 ‘Taylor” reported that fluoride might induce ‘CANCER’.
- 1960 Fluorosis is confirmed in Punjab, AP, Tamilnadu, Uttar Pradesh & Delhi

History: contd....

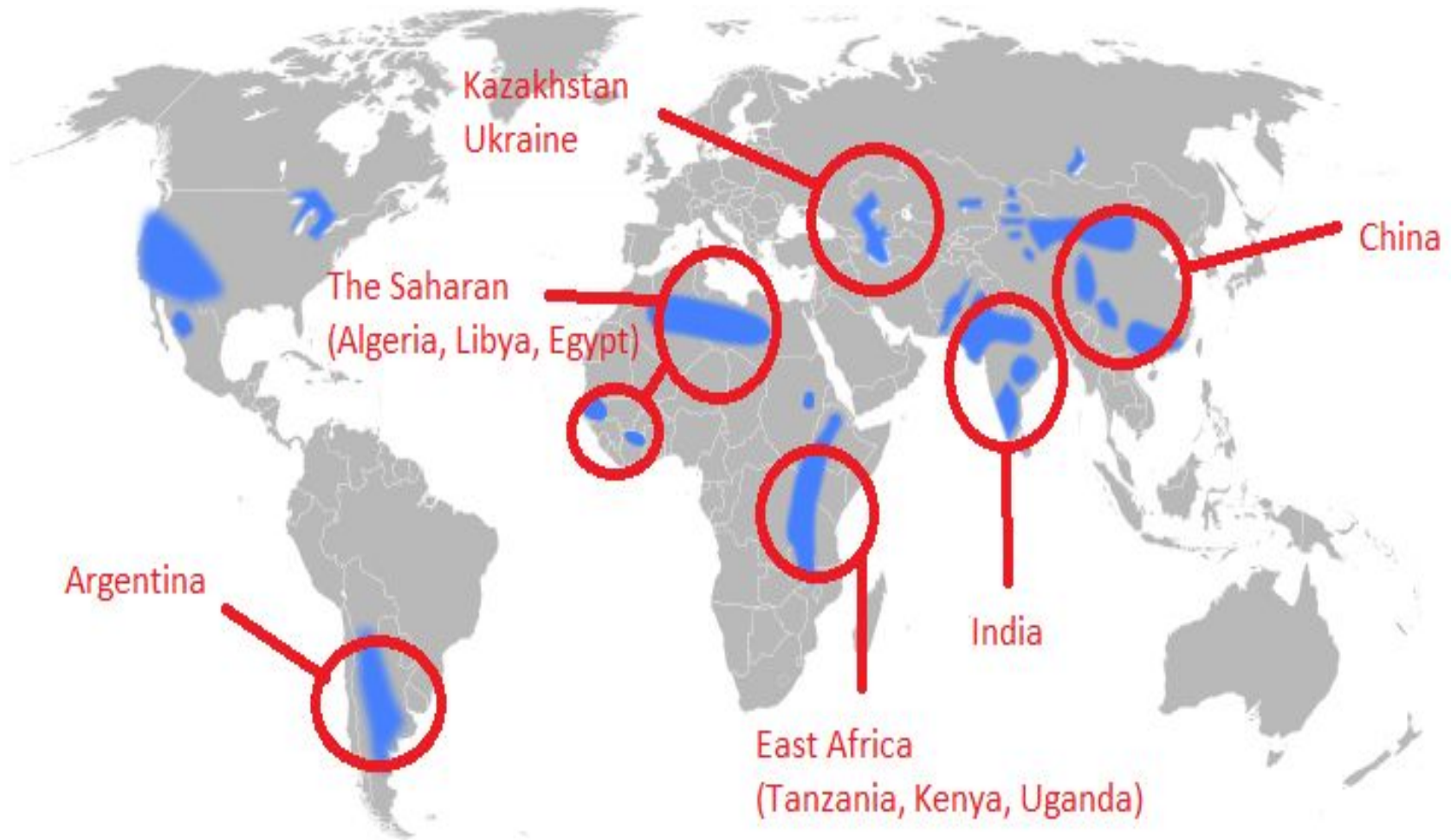
- 1976 'Mohamed' a researcher stated that ' The presence of fluoride in water may represent a 'GENETIC HAZARD TO MANKIND'
- 1977 'Forseman' found that 82% of children fed with tinned milk and food are suffering from Fluorosis.
- 1981 'Emsley' showed that fluorides are capable of entering a chemical reaction with DNA & RNA
- 1960 - 1980 Fluorosis is detected in Rajasthan, Haryana, Gujrat, Karnataka, MP, and Delhi.
- 1980 - 1987 Fluorosis is detected in Bihar, Orissa and Maharashtra

Endemic Fluorosis is world wide.

➤ The following countries have been identified for the problem of fluorosis:

- India, Pakistan, Bangladesh,
- Argentina, United States of America,
- Morocco, Middle East Countries, Japan,
- China, South African Countries,
- New Zealand, Thailand etc

Fluorosis Worldwide



Sources of Fluoride:

- *Food*: Fluoride content is high in vegetables grown in endemic areas of India.
- *Water*: Surface water contains low fluoride.
- Ground water has high concentration of fluoride.
- Sea water contains 0.8 to 1.4 ppm and hence sea foods contain more fluorides.

- *Air*: Atmosphere has very low FI content and in 97% of non-urban areas, it is hardly detectable.
- It rises in volcanic conditions, industrial emissions like Aluminum, Cryolite and Coal which are dangerous.
- Low grade coal has high levels of FI and smoke is the source of Fluoride toxicity.
- Safe intake of FI for adults is 1.5 – 4 mg / day

- *Drugs*: Prolonged use of Sodium Fluoride for treatment of Osteoporosis, Niflumic acid for treatment of Rheumatoid arthritis and also mouth rinse.
- *Cosmetics & Toothpaste*: Certain cosmetics & toothpastes also contain significant amounts of FI.
- *Others*: Inorganic FI compounds are used in the production of Aluminium & Phosphate fertilizers.
- Tea has an exceptionally high FI content & bottled beverages also have variable contents of Fluoride.

Absorption & Distribution of Fluoride:

- Fluoride that is ingested is rapidly absorbed through GIT & lungs.
- The peak effect is obtained within 30 mins in blood.
- If more than 5 mg is ingested, then 50% of it is retained by bones & the rest is excreted in urine.
- Rapid excretion takes place through renal system over a period of 4 to 6 hours.

- About 10 to 25% of Fluoride intake is excreted by faeces.
- Fluorine in plasma exists in free ionic form & also bound to S. Albumin forming about 85% of total amount.
- In non- fluorinated areas, it ranges from 0.14 to 0.19 ppm. This will be higher in Fluorotic patients.
- Normal ionic levels in plasma are lower (0.004 to 0.008 ppm)

- In children less than 3 yrs of age, only 50% of total absorbed amount is excreted.
- In adults it is 90% which is retained in the body & is deposited in the skeleton & teeth.
- The biological half life of bound fluoride is for several years.
- Fluoride passes through placenta and also appears in low concentrations in saliva, sweat & milk.

Indian Scenario

- The problem has reached alarming proportions.
- Around 25 million people in 19 states and union territories of the country are affected by fluorosis.
- 186 Districts in India are affected out of which maximum are in Rajasthan, followed by Orissa, Punjab, Andhra Pradesh, Tamilnadu, Uttar Pradesh & Gujarat.
- Experts say that another 66 million are at risk including 6 million children below the age of 14.



- LEGEND**
- (●) Less than 30% of districts affected: 4 states
 - (●●) 30 - 50% districts affected: 5 states
 - (●●●) 50 - 100% districts affected: 5 states
 - (▲) disease not detected

Incidence of Fluorosis in Different States of India

Fluorosis

- It came into light because of dental Fluorosis.
- It involves mainly enamel.
- Yellowish brown discoloration is the earliest sign followed by Mottling.
- Teeth become rough, opaque and chalky white resulting in pitting and chipping.
- Both sexes are equally affected

Mild & Severe types of Fluorosis



Chalkiness of teeth



Brown stain on teeth



Brown wavy striations on teeth



Severe mottling

Clinical Features depend on the systems affected and the clinical presentation may be acute or chronic.

Acute toxicity

- After ingestion of Fluorine in high doses, there are s/s of irritant poison.
- There is diffuse abdominal pain with diarrhea & vomiting.
- Excess salivation with thirst, perspiration & painful spasm in the limbs.

- Acute Lethal dose of FI for man is 5 gms of NaF.
- Treatment depends on the clinical condition, immediate gastric lavage & replacement of the electrolytes.
- Consider haemo dialysis in patients with significant toxicity who do not respond to antacids to bind with Fluorides.

Chronic toxicity

- Occurs due to constant exposure to high fluoride foods and fumes.
- It may manifest as dental fluorosis, skeletal fluorosis and non-skeletal which includes
 - Cardio-vascular system,
 - Respiratory system,
 - Renal system,
 - GIT and CNS along with
 - Allergic manifestations.

Haemopoitic system:

- When fluoride is ingested, it accumulates in the erythrocyte membrane besides other cells, tissues & organs.
- The erythrocyte membrane loses its calcium content.
- RBC become pliable and destroyed in the form of echinocytes resulting in anemia.
- The RBC loses its shape & life span.

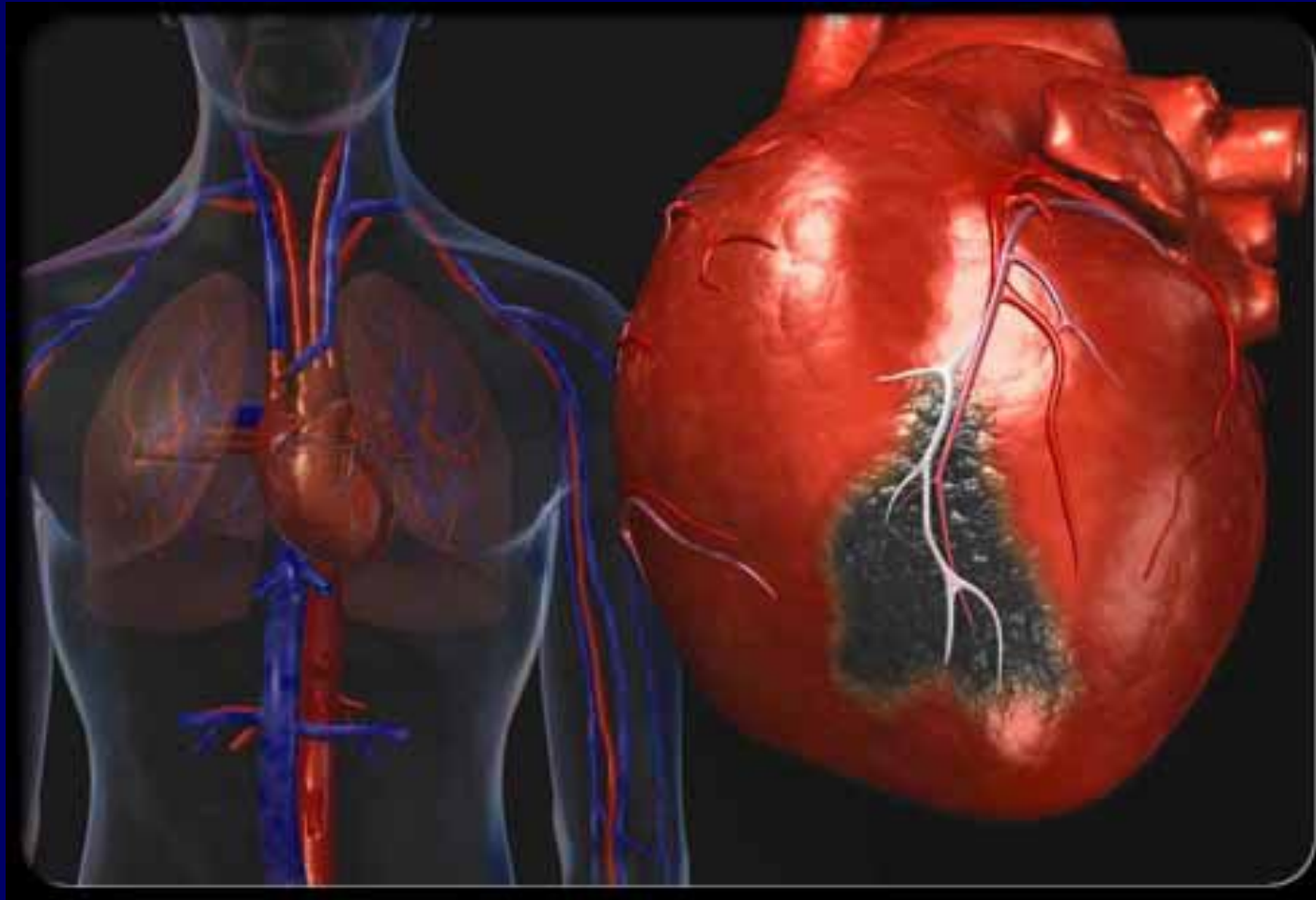
Cardiovascular system:

- Aorta is commonly affected & is known to accumulate very high concentrations of Fluoride.
- Smaller arteries are also affected due to calcification of blood vessels leading to hypertension.

Pregnancy:

- Due to impairment of placental circulation & calcification of fetal vessels, results in abortions, arresting the growth of fetus and still births.

Effect on Heart & Aorta



Gastro Intestinal Tract:

- Gastro intestinal Mucosa has cracked clay appearance.
- There is loss of micro villi from mucosal surface, disappearance of mucous giving non ulcer dyspeptic signs & symptoms like
 - Nausea & headache followed by vomiting.
 - Loss of appetite,
 - Pain in the stomach,
 - Gas formation with bloated feeling,
 - Constipation followed by intermittent diarrhea.

Polydipsia & Polyurea

- It was initially mistaken for DM.
- It was found that the blood sugar levels were not elevated, could result in abnormalities in Glucose tolerance which were reversible.
- The same changes were found in patients suffering from skeletal fluorosis and in patients undergoing fluoride therapy for 3-12 months.
- In high fluorine areas, thyroid enlargement prevalence was noted.

Skeletal Muscle involvement:

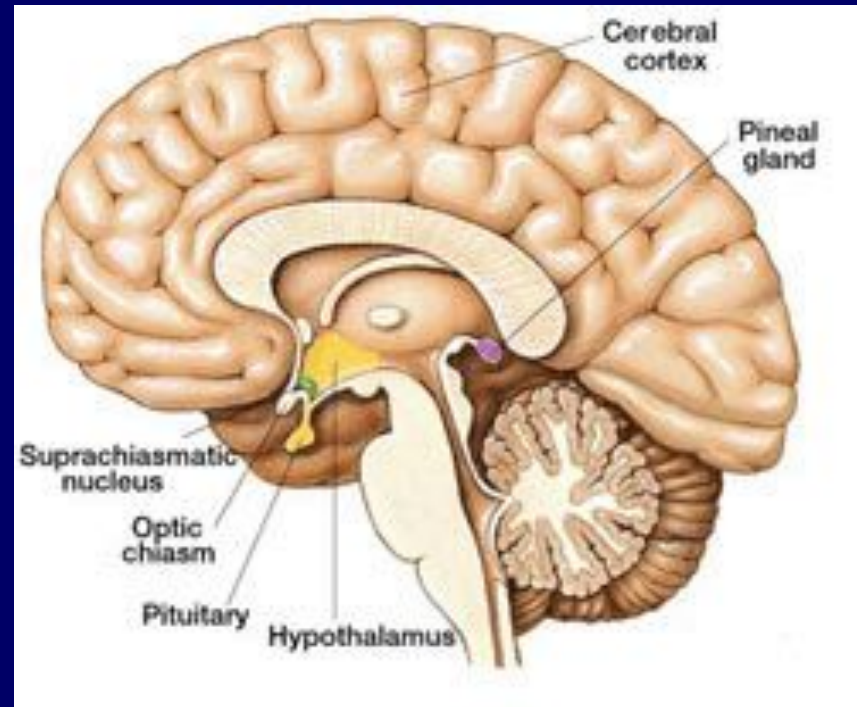
- Muscle proteins Actin and Myosin are not laid down as Fluoride inhibits, the enzymes leading to derangement of protein biosynthesis.
- Generalized atrophy of skeletal muscle is observed.
- Muscle mitochondria are destroyed and membranes become highly permeable – **leading to muscle weakness with inability to walk.**

- Calcification of ligaments & connective tissue occurs.
- The soft covering of the bone become thick strings that are immobile and can be easily felt.
- They are also visible in the radiographs.
- Exostosis develops around knee, elbow & ankle.
- It may press upon median, ulnar nerves and stiffness soon spreads to lateral popliteal nerves thus causing Peripheral neuropathies.

Neurological Manifestations:

- Radiculo Myopathy arises because of mechanical compression of spinal cord nerves in the intervertebral foraminae.
- Among the Cranial Nerves, 8th nerve is affected causing deafness.
- Calcification of major vessels and disturbance of lipid metabolism may lead to Basal Ganglion & Cerebrovascular accidents.

Neurological Manifestations



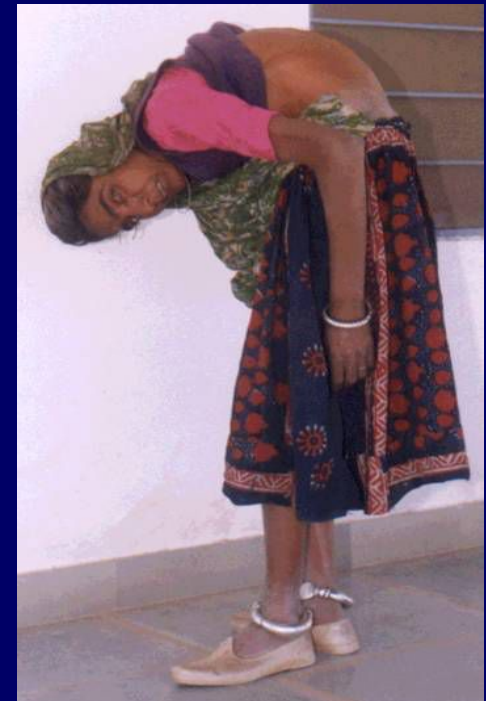
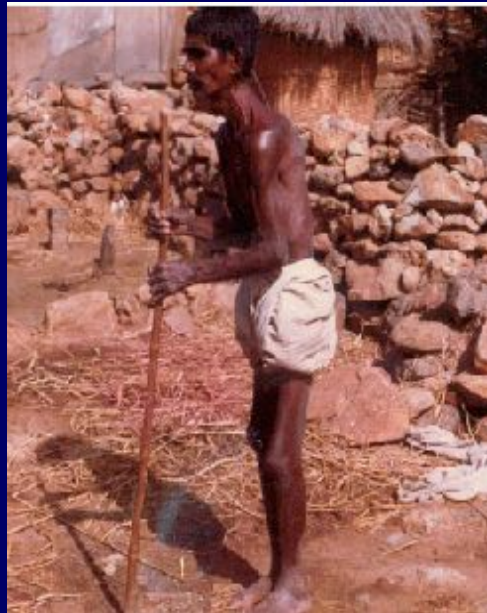
Skeletal Fluorosis

- Fluoride has high affinity for calcium phosphates & therefore accumulates in the bone.
- Patients often c/o vague discomfort and parasthesiae in the limbs & trunk.
- Pain & stiffness in the back especially in lumbar region followed by dorsal & cervical spine.

- Restriction of spine movements is the earliest clinical sign of Fluorosis referred as “Poker back” (Murray1950)
- The stiffness spreads to various joints, capsule, related ligaments, tendinous attachments to the bones & interosseous membrane.
- Flexion deformities develop at knees, ankle **making the patient bedridden.**
- Diagnosing Skeletal fluorosis – Roholm’s Phases of Bone Changes detectable on X ray.

Skeletal Fluorosis - Deformities

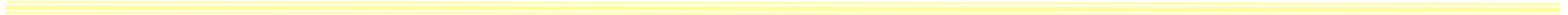




Stenotic Changes



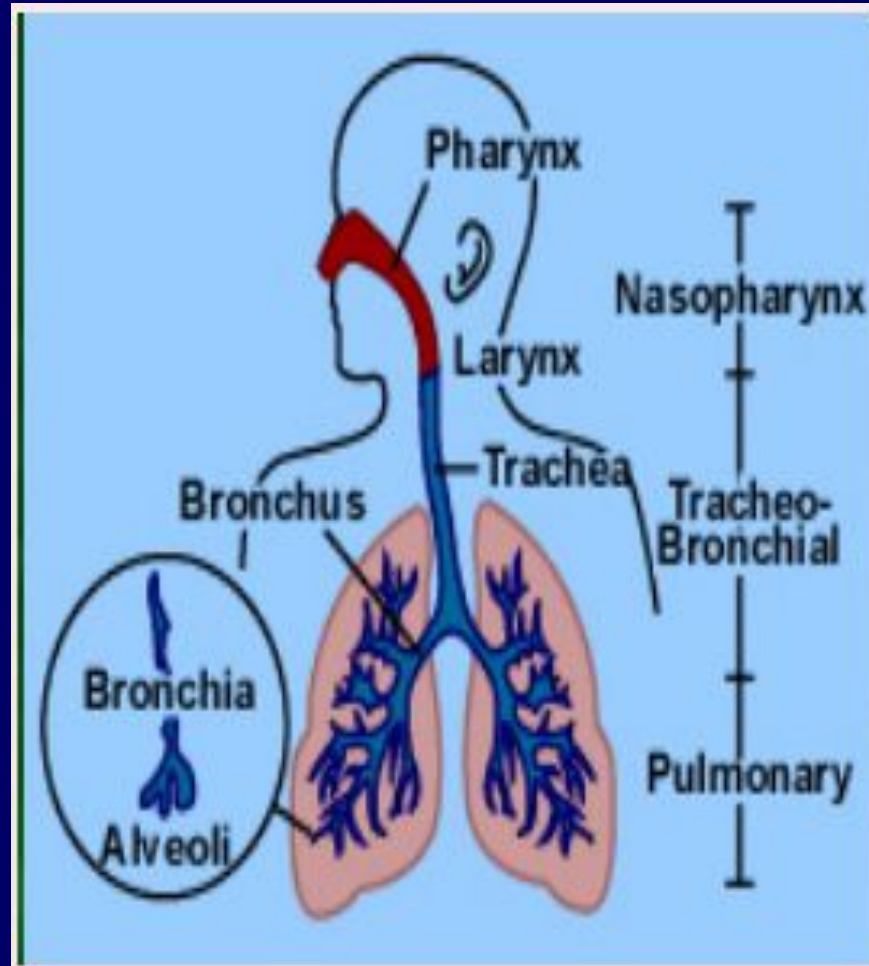
**Lumbar
Stenosis**



Respiratory System:

- Due to the involvement of ribs, chest assumes barrel shape and respiratory movements gradually decrease & thus vital capacity is reduced.
- This results in Restrictive Pulmonary Disease.
- Some salts of fluorides have been associated with increased incidence of asthma, bronchitis and other Chronic Obstructive Lung Diseases.
- Smoking aggravates symptoms 2 - 3 times.

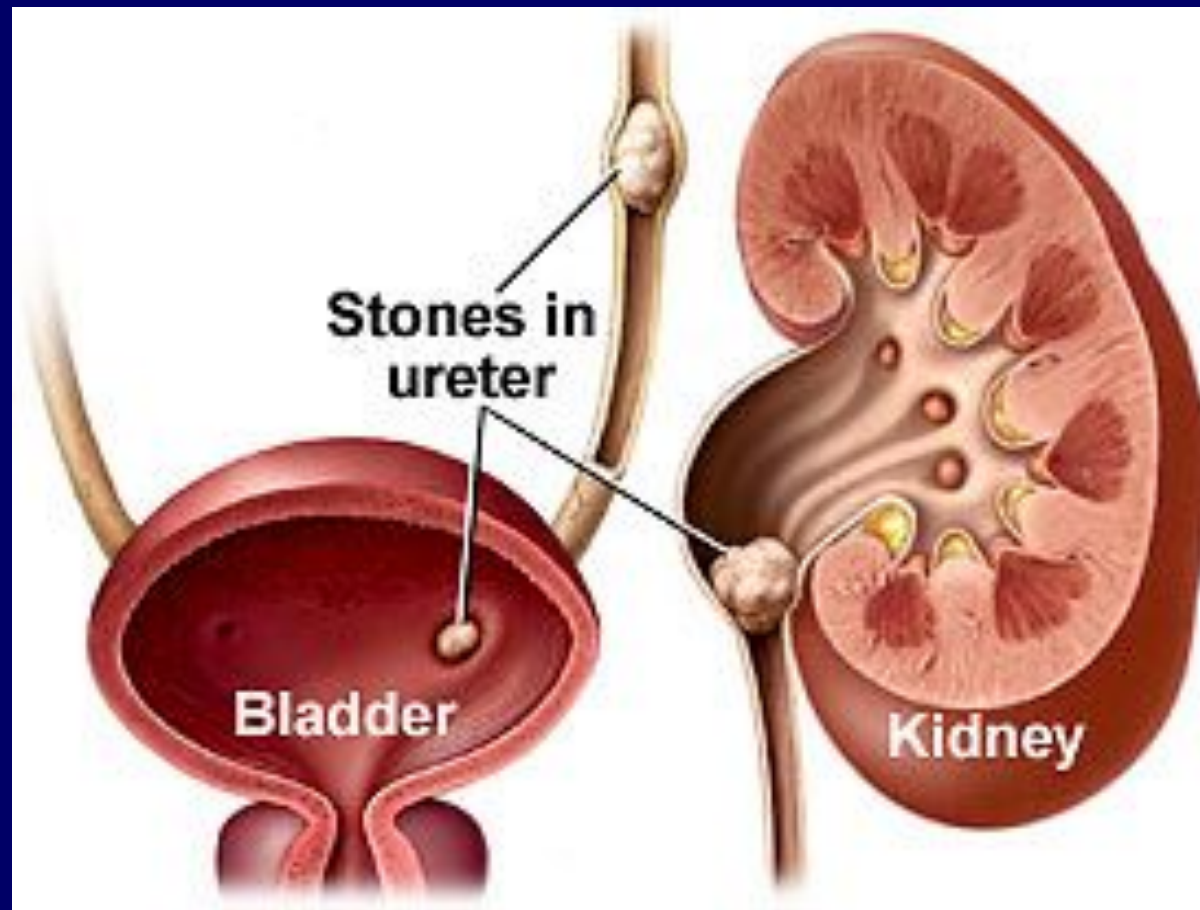
Respiratory System



Renal System:

- Disturbed renal function predisposes to excessive retention of fluoride.
- Individuals suffering from CRF may develop skeletal fluorosis even at low level of 1 ppm in drinking water.
- Immune system gets affected & cases of Cancer have been reported.

Vesical, Ureteric & Renal Calculi



Pre anaesthetic evaluation

History about joint pains, endemic areas etc is important.

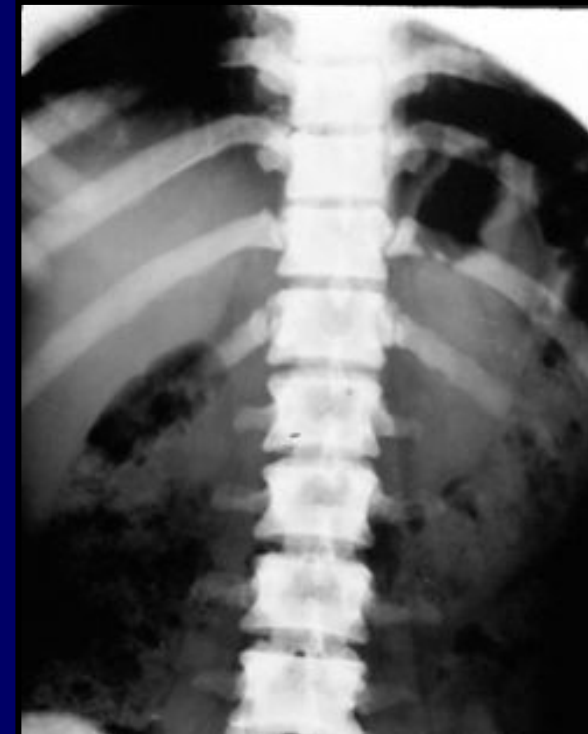
We require some basic and special Investigations.

- *Haemogram* – which shows mild to severe anaemia. Hence whole blood and packed cells should be available.
- *Serum Calcium* is raised & S.Alkaline phosphatase is elevated.
- *Renal function tests*- Impaired Urea clearance, decreased glomerular filtration, increased BUN.

X-ray Diagnosis of Skeletal fluorosis



X Ray of the Spine



Chest X ray

➤ *Radiological findings:* seen during puberty & adulthood. Osteopenia is noted & Sclerotic areas of the Meta physeal ends simulate renal rickets.

➤ *Electrophysiological studies:* EEG & EMG

➤ *Fluoride estimations:* Fluoride in water consumed & 24hrs levels in urine are best indicators.

Serum fluoride levels can now be estimated.

- *Histo pathological Evaluation* : Bone biopsy and Muscle biopsy
- *Pulmonary Function Tests* – Reduced VC & FEV1 / FVC ratios. Respiratory curve of flow volume loop is flattened in late stages.
- *Scintinographic studies* – Radio nucleotide bone scans by technetium labeled methylene diphosphonate seen only in fluorotic cases.

- *CT Scan* – Spinal canal & root canal stenosis.
- *MRI*: for associated anomalies – Fluorotic vertebrae
– hypo intense. Localised hypertrophy & ossification
of ligaments can be visualized.
- *Myelography* – rarely performed now a days

ANAESTHETIC IMPLICATIONS:

General Anesthesia :

- It is better to administer pro-kinetics & antacids.
- Always better to have a Ryle's tube prior to induction.
- **Almost all inhalational agents contain fluoride and are to be avoided as far as possible.**
- **IV line may be difficult to obtain** because of rigid joints & rigid muscles and abnormal bony deformities.
- **Difficulty in intubation** because of rigid C.Spine.

- Some pts cannot rest their head on pillow.
 - Accidental fall of teeth during forced intubation.
 - Many supra glottic devices are in use now.
(LMA, ILMA, Proceal LMA are available)
 - Retrograde intubation may not be possible.
 - Tracheostomy may also be difficult.
 - Fibro optic intubation is ideal.
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- Always keep difficult airway cart handy.
- Markedly reduced Pulmonary function (Restrictive Pulmonary Disease & COPD) may require attention.
Preoxygenation for longer period is recommended.
- **Rapid sequence technique** to be adopted due to histopathological changes in GIT.
- Most of the Induction agents can be titrated and safely used. TIVA is ideal for minor procedures.

- Ketamine is **not advisable** due to muscle rigidity and psychotic side effects.
- Major surgeries require relaxants which may react differently.
- Relaxants may be required more than the usual dose.
- One should be always be prepared to ventilate them for longer periods because of pulmonary conditions & decreased renal excretion.

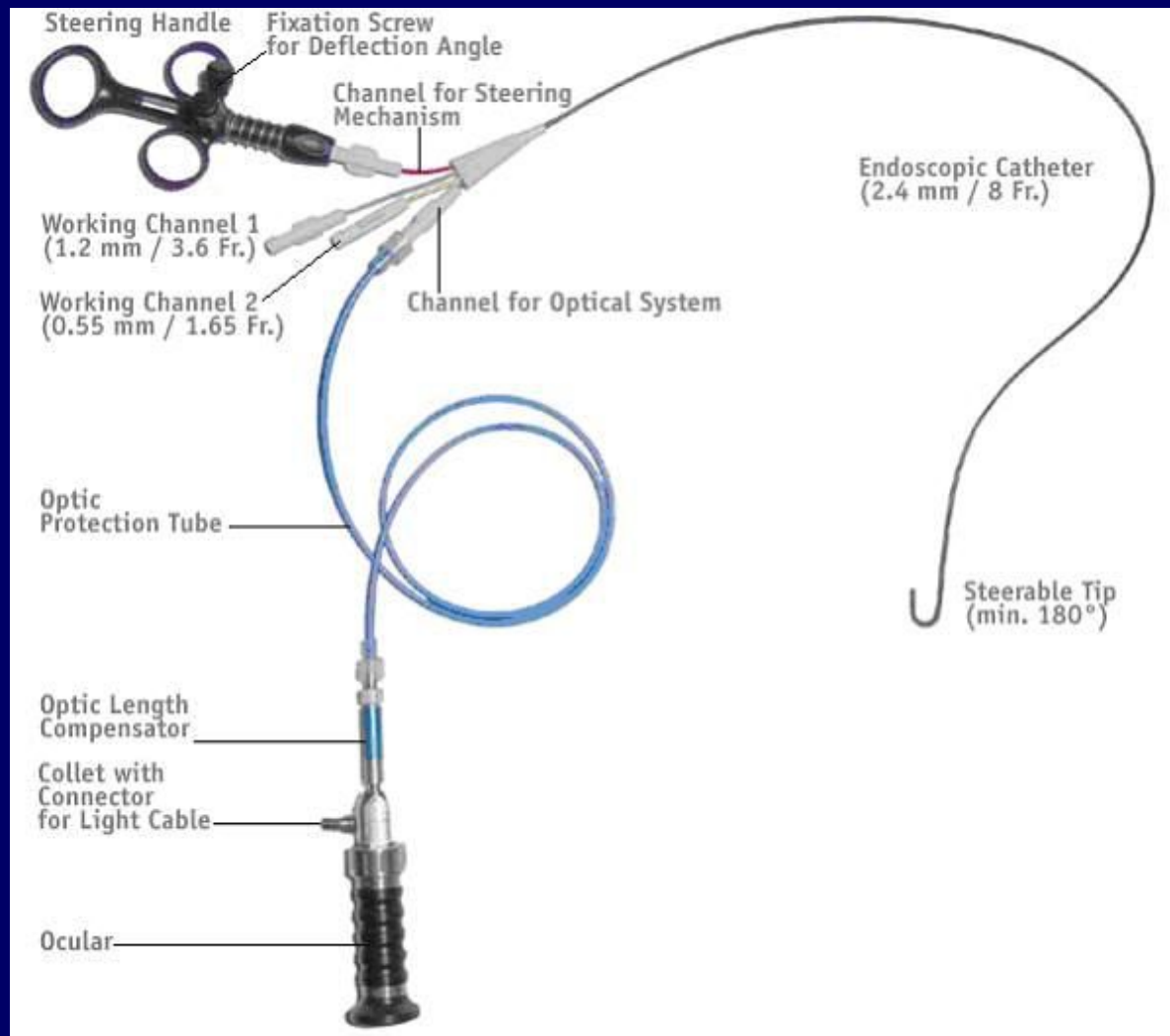
- Most of the Volatile agents contain Fluoride, hence must be avoided; or used with CAUTION.
- The doses of all the drugs, premedicants, inducing agents, must be reduced as the Renal function is impaired & to avoid Nephrotoxicity.
- Always have a second Anaesthesiologist's help during intubation & also recovery.

REGIONAL BLOCKS

- Spinal may be difficult because of the bamboo spine.
- Lateral approach may be helpful in most of the cases.
- Too fine needle may not be useful. So 23G or 24G needles are ideal.
- Attempting to go for Nerve Block without Ultrasonic or Nerve Locator is not advisable.

- Epidural Space is also narrowed because of the Fluorotic changes in the space.
- Negotiating catheter is difficult; hence it is better to take the help of Epiduroscopy whenever possible & available.
- Smaller catheters of good quality will be helpful.

Epiduroscope



Defluoridation Techniques

- *Addition of Tamarind*: In KENYA where fluoride content is more than 100 ppm, addition of Tamarind decreased fluoride by 50% after 24 hours.
- *Activated carbon Treatment*: Carbon from saw dust removes 350 – 450 mg/kg of dry material. Ions like Cl, SO₄ reduces fluoride removal capacity.
- *Treatment with Alumina*: Removal by a monolayer adsorption process at optimum pH was reported as 84%. A total capacity of 12mg/gm of alumina shows remarkable variations.

- Lime Treatment: was found to be working well only for the removal of HF from the effluent. 5000 ppm FI is reduced to < 8 ppm FI by 35,000-ppm lime.
- Treatment with Aluminum Salts: A solution of Al salts is used with FeCl_3 as flocculants.
- MgCl_2 salt : at 2.0 g per liter added to waste water containing 50 ppm fluoride reduces it to 3 ppm.
- Nalgonda Technique: Alum & Lime were added to precipitate the Fluoride.
- Ion exchange process: H_2O containing FI is passed through a bed of ion exchange resin, which selectively adsorbs fluoride from the water.

- Electrolysis Treatment: A mixture of calcium compound 10 g & diatomaceous earth 20g in 1000 liter is used for defluoridation. Formation of CaF_2 colloids to be absorbed on to the diatomaceous earth. Treated water fluoride was 0.4 ppm.
- Treatment with Na_2CO_3 & $\text{Al}_2(\text{SO}_4)_3$: is totally dependent on hardness in the water.
- By Membrane Separation – Reverse Osmosis successfully defluorinated water containing high Fluoride content. Resin is regenerated after exhaustion & is economical.

“Prevention is better than Cure”

- This is not a completely curable disease once crippling occurs.
- In the initial stages treatment depends on intake of good nutrition.
- Vitamin C, D & E, Calcium containing products and anti-oxidants.
- Testing the fluoride content in the water will be helpful.

- In most of the districts, large scale treatment of drinking water to reduce fluoride content is taken up.
- Government and Regional labs have now set-up to conduct the tests for water, urine & serum.
- Thus preventing Fluorosis by providing safe drinking water in our districts.

As Anaesthesiologist, though not directly involved in the treatment perse, needs to know about the various pathological changes to deal with the management of the cases for correction of deformities, or any other surgical procedures thus avoiding morbidity & mortality.

References

1. *Fluorosis in Andhra Pradesh – Fluorosis Vimukthi Vedika; Dr. D. Raja Reddy – Srikanth Deme*
2. *2008 – Deccan Chronicle – Fact file; Page 2*
3. *2006 – Irritable Bowel Syndrome & Fluoride Toxicity.*
4. *2005 - Prof. Dr. A. K. Susheela, Fluorosis Research and Rural Development Foundation, Delhi. Workshop conducted at Osmania Medical College, Hyderabad.*
5. *2003 – Fritschi L. Etal ;International Archives of Occupational & Environmental Health; 76 (2) 103 – 10*
6. *2000 – Romund Petal ; Non-malignant mortality among workers in Aluminum plants; Scandanavian Journal of Work environment & Health*
7. *1997 – 98; PHED – Habitation Survey.*
8. *1992 - Fluoride ingestion and its correlation with Gastro-intestinal discomfort. Fluoride.*
9. *1992 – Prevelance of Respiratory Disorders among Aluminum potroom workers in relation to exposure to fluoride; British Journal of Industrial Medicine 125 – 130*
10. *Anaesthesia for Uncommon Diseases by Jonathan Benumof; Fluoride – Carditis.*
11. *Miller 5th Edition, Volumell.*
12. *Park's Textbook of Preventive & Social Medicine – 16th Edition.*
13. *“Eradication of Fluorosis in India” – Dr. R. Jagadiswara Rao, Former Prof. of Geology, Sri Venkateswara University, Tirupati.*
14. *Journal of Indian Water Works Association Jan. – March 1994*
15. *Journal of Indian Water Works Association July. – Sept 1999*
16. *Journal of Indian Water Works Association Jan. – March 1986*
17. *An Overview of Deflouridation methods J. IPHE, India 1988*
18. *ENCOLOGY Vol. 9, No. 4 September 1994*
19. *Deflouridation of water Ind.Jou. Env. Health Vol. 32, No. 3 , 1990*
20. *Indian Journal of Env. Health Vol.35, No. 1, 1993.*

Thank you