Nutrition in Cystic Fibrosis

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Objectives

- Cystic fibrosis (CF) - genetics, disease background
- **Reasons for malnutrition unique to CF**

  -pancreatic insufficiency

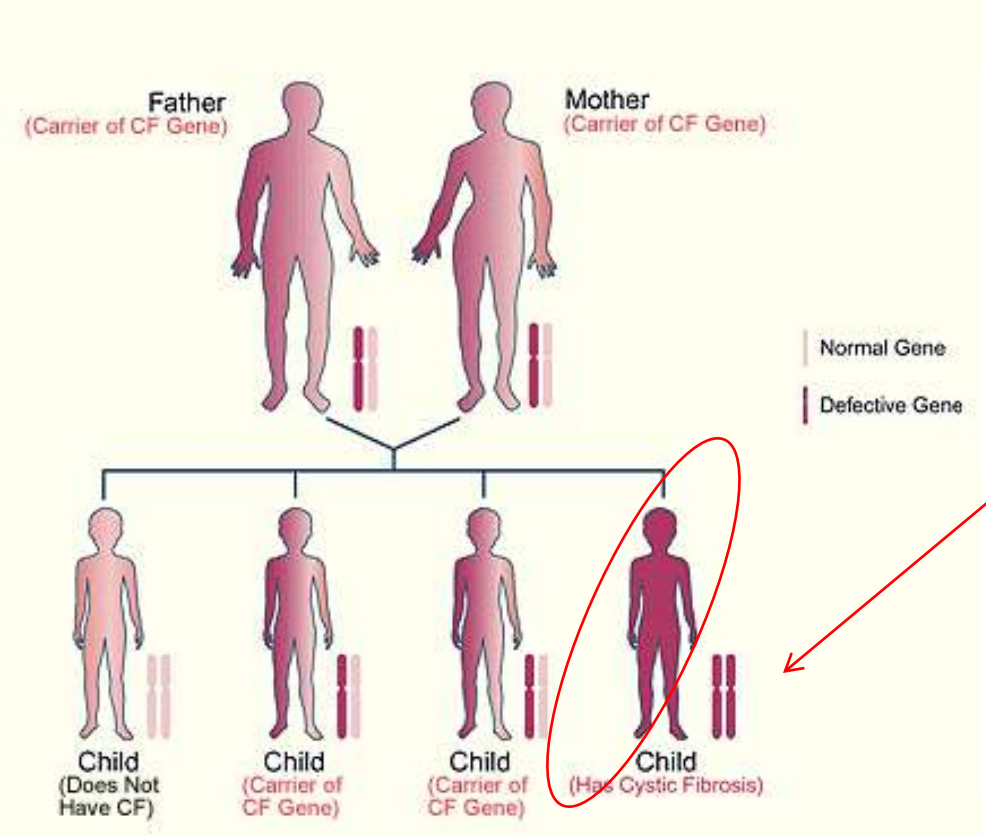
  -recurrent infections

  -CF related diabetes

- Nutritional status and its relation with clinical outcomes
- **Evidence for nutritional strategies in CF**

Inheritance of Cystic Fibrosis

- Genetic disorder- inherited in autosomal recessive manner

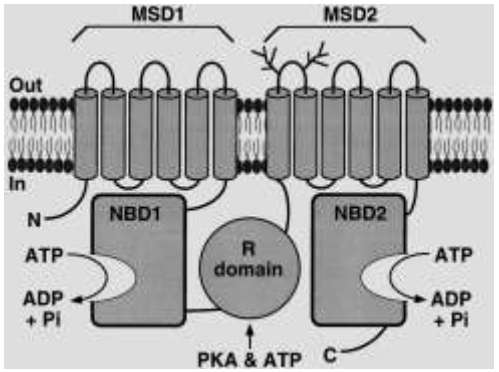


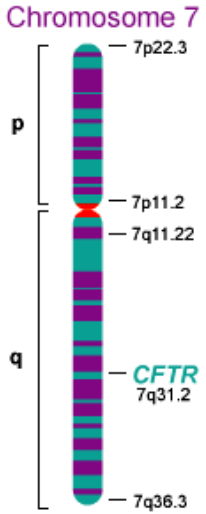
Both parents are carriers for CF

Child must inherit both genes to have CF

1 in 4 children will have CF
2 will be carriers for CF
1 will be normal

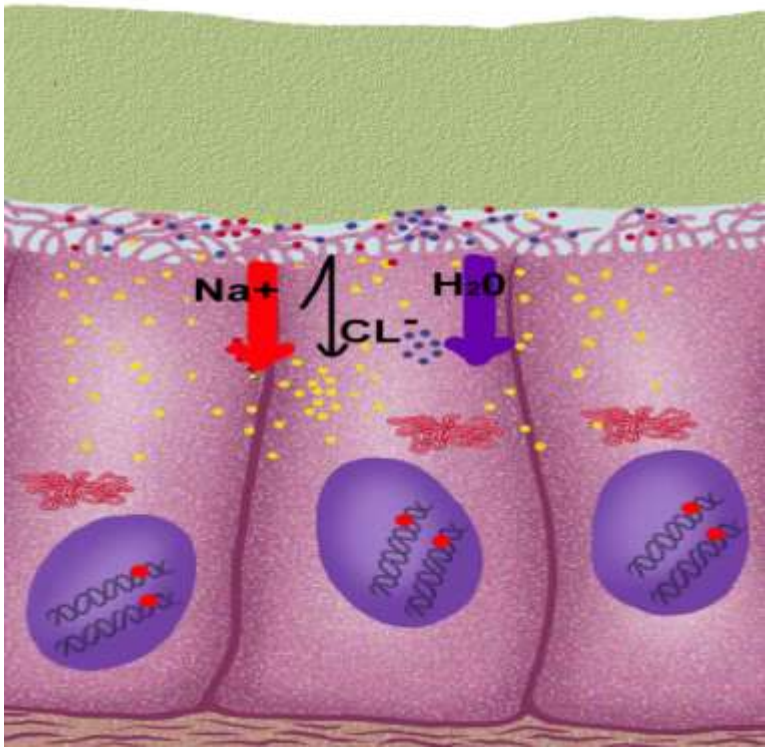
Genetics of CF





- Caused by mutation in CFTR gene, chromosome 7
- **CFTR= cystic fibrosis transmembrane regulator**

- Encodes chloride channel and ion conductance regulator → defect in epithelial ion transport in various organs

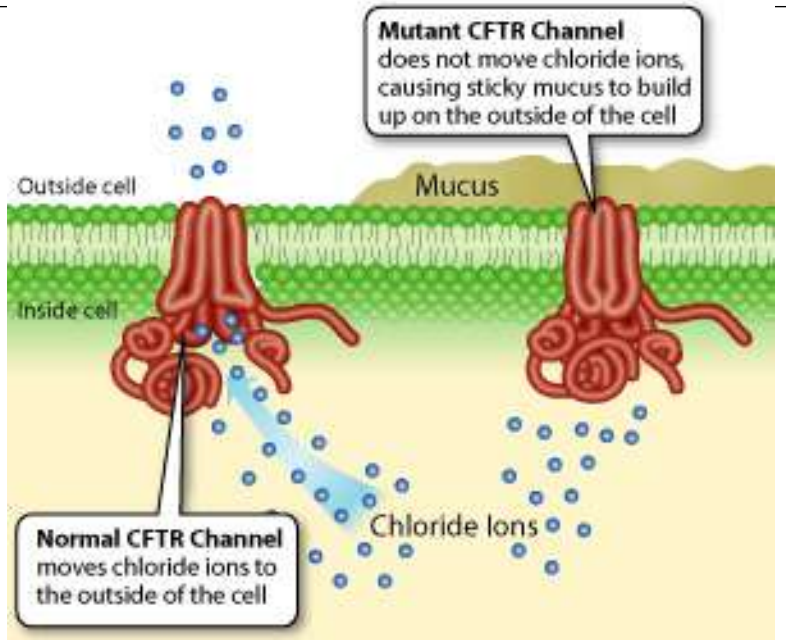


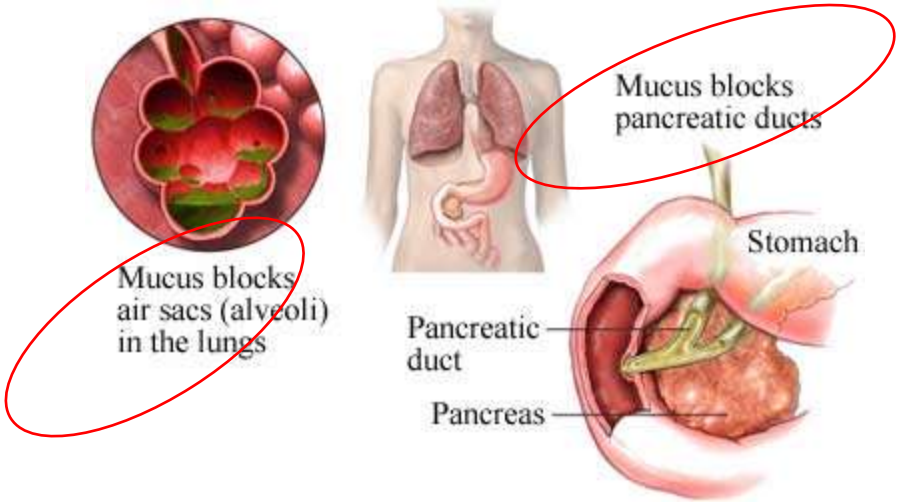
Hallmarks of CF

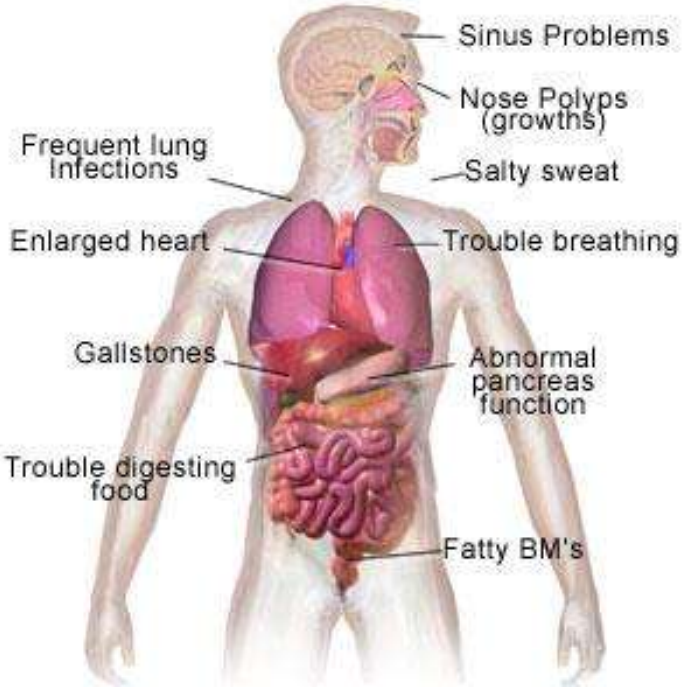
Chronic respiratory disease

- **Pancreatic insufficiency**
- **Fat malabsorption**
- **Failure to thrive**

Elevation of sweat chloride







Cystic Fibrosis today

- **30,000 affected individuals in US**
  -1 in 2500 Caucasians
  -1 in 15,000 African Americans
- **1 in 25 unaffected Caucasians are carriers**

- **Median age : 15.9 yrs**
- **Median predicted survival : 36.5 years**

- **Respiratory disease is the major cause of morbidity and mortality in CF**

Authors	No of Pat	Diagnosis
Bhakoo et al. 1968	01	Histopathology
Mehta et al. 1968	13	Sweat test
Mehta et al. 1969	06	Sweat test
Devi et al. 1969	04	Sweat test
Gupte et al. 1970	06	Sweat test
Reddy et al. 1970	12	Autopsy
Venkatraman et al 1972	01	Autopsy
Goodchild 1974	03	Sweat test
Maya PP et al 1980	03	Sweat test
Jagdish JS. 1989	01	Sweat test
Prasad ML et al 1990	02	Autopsy
Deivanayagam CN et al 1990	05	Autopsy
Sarkar AK et al. 1992	01	Sweat test
Bowlers 1993	09	Sweat test
Spencer et al 1994	13	Sweat test
Powers et al 1996	20	Sweat test
Kabra et al 1996	15	Sweat test
Kabra et al 1996	13	Mutations
Kabra et al 1999	62	Sweat test
Kabra et al 2000	24	Sweat test
Singh et al 2002	18	Sweat test
Ashavaid TF et al 2003	5	Sweat test and mutations
Kabra et al 2003	120	Sweat & mutations
Ashavaid etal 2005	39	Sweat &mutations

CF reported from India

Slide and data from Dr Sushil K. Kabra AIIMS, Delhi

Indian Pediatrics 2002; 39: 813-818.

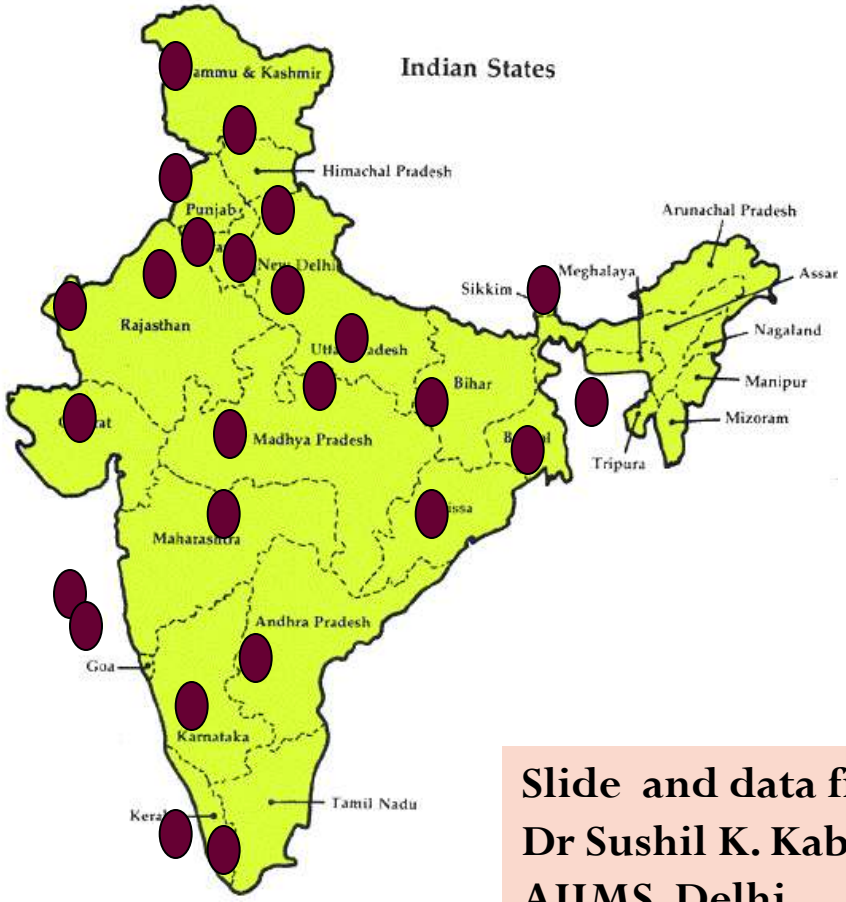
CF at AIIMS: 1995-2010

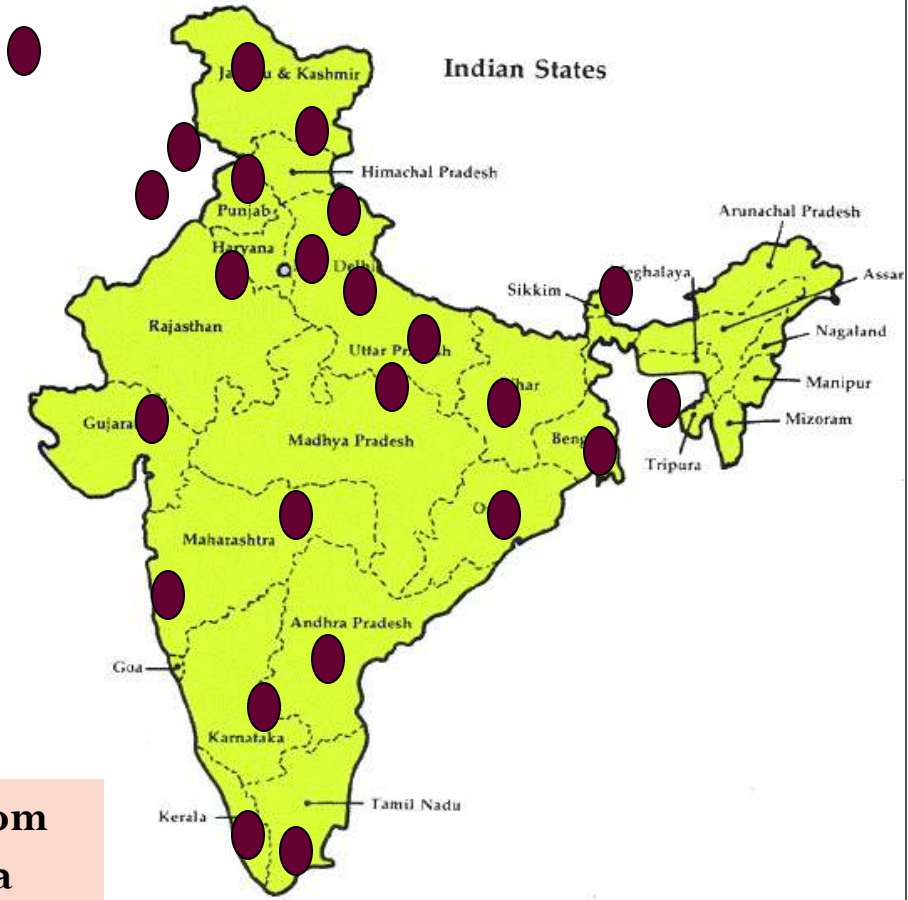
Slide and data from
Dr Sushil K. Kabra
AIIMS, Delhi

- Total diagnosed till 2010 — 355
- Died — 45
- Lost to follow up — 95
- Irregular follow up — 110
- Regular follow up — 100
- Oldest patient — 34 years
- Median age 2010 — 10 years
- Age > 15 years — 20%

CF at AIIMS: place of origin

CF at AIIMS: place of residence





Slide and data from
Dr Sushil K. Kabra
AIIMS, Delhi

Indian Pediatr 2003; 40: 612-619

Slide and data from
Dr Sushil K. Kabra
AIIMS, Delhi

Magnitude of the problem in Indian population

- Estimated frequency of disease in immigrant Indians
  - in UK 1: 10000 – 12000
  - in USA 1: 40750 (compared with 1:3300 Caucasian)

- **Carrier rates in India**
  - 950 cord blood samples were tested for carrier status of D F 508 mutations.
  - 4 samples were positive for D F 508
  - Delta F 508 vary from 19-34% in CF patients
  - **The frequency of CF in India is about 1:40000**

J Cyst Fibrosis 2006; 5: 43-46,

Slide and data from
Dr Sushil K. Kabra
AIIMS, Delhi

Estimates of CF in India

- Population of India: 1000000000 (one billion)
- Birth rates: 20 per thousand per year
- Total births per annum: 20,000,000
- Number of children with CF per annum

Frequency	Estimated CF cases per year
1:2500	8000
1:10000	2000
1:40000	500

- *Majority are likely not diagnosed, and do not receive proper treatment*

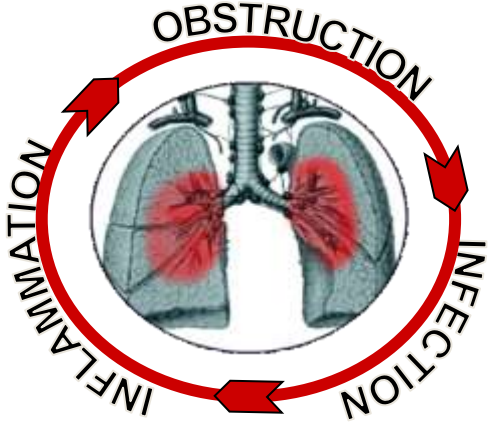
CF patients followed at Apollo Hospital, Hyderabad

- Total : 8 children ; 6 boys, 2 girls
- Ages: 6 mths, 3 yrs, 7 yrs, 8 yr, 10 yr, 10 yr, 11 yr, 16 yr

- Except the infant, all have bronchiectasis of the lungs due to repeated lung infections
- One has advanced lung disease on home oxygen
- All are pancreatic insufficient on enzymes
- 2 have normal height and weight
- Rest are underweight and have reduced height for age

CF: clinical course and complications

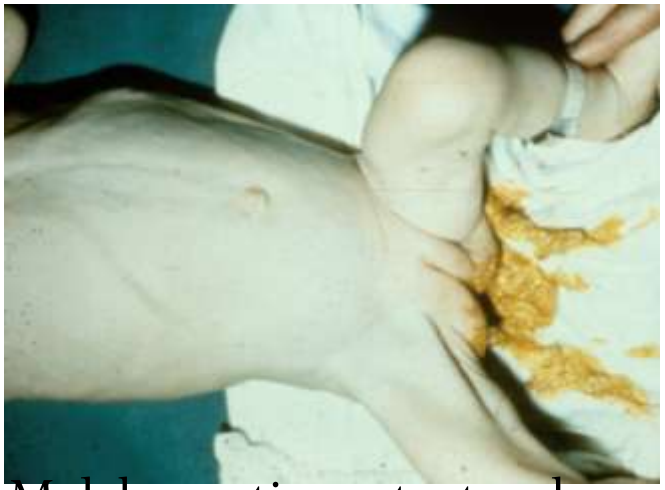
- Chronic cough, pulmonary exacerbations of CF
- Recurrent respiratory infections, pneumonia



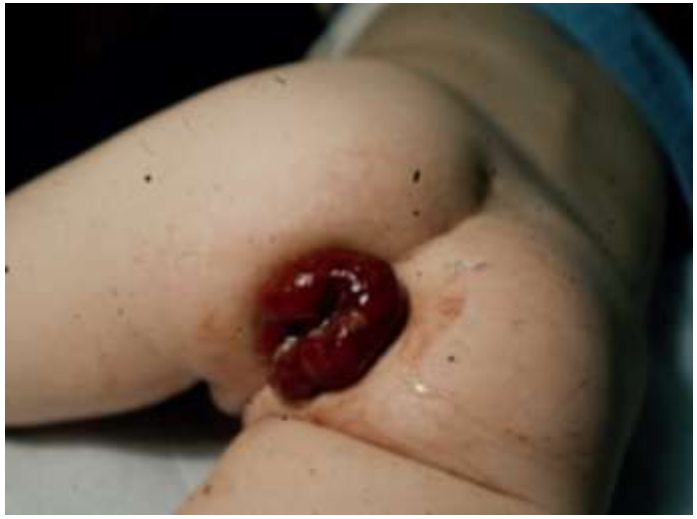
- **Pancreatic insufficiency**
  -exocrine- (α cells) fat malabsorption
  -endocrine- (β cells) CF related diabetes (CFRD)

- **Liver disease**- biliary cirrhossis, hypoalbuminemia

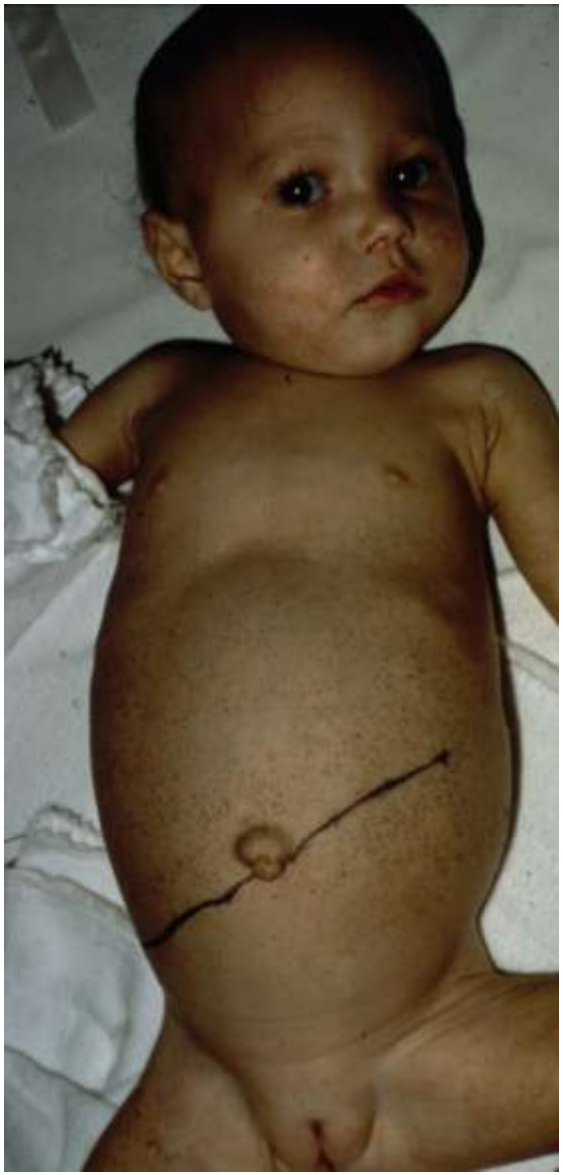
CF: Pancreatic insufficiency

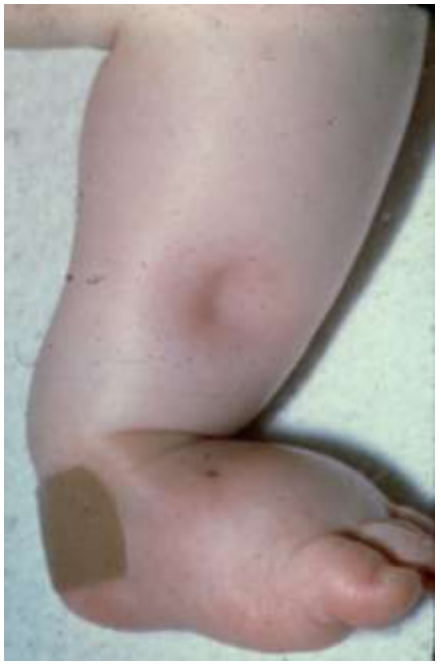


Malabsorption, steatorrhea



Rectal prolapse

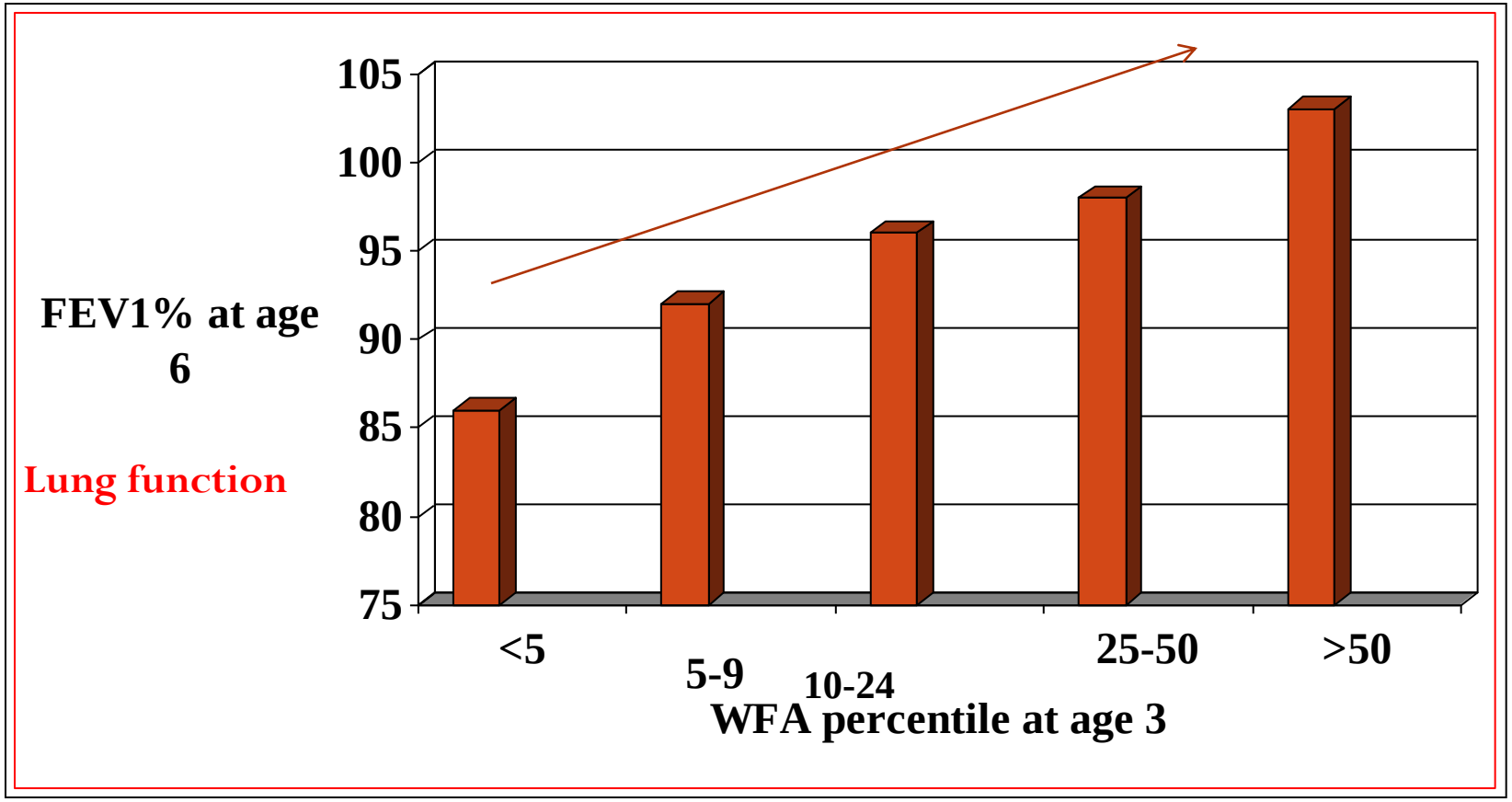




Malnutrition – edema

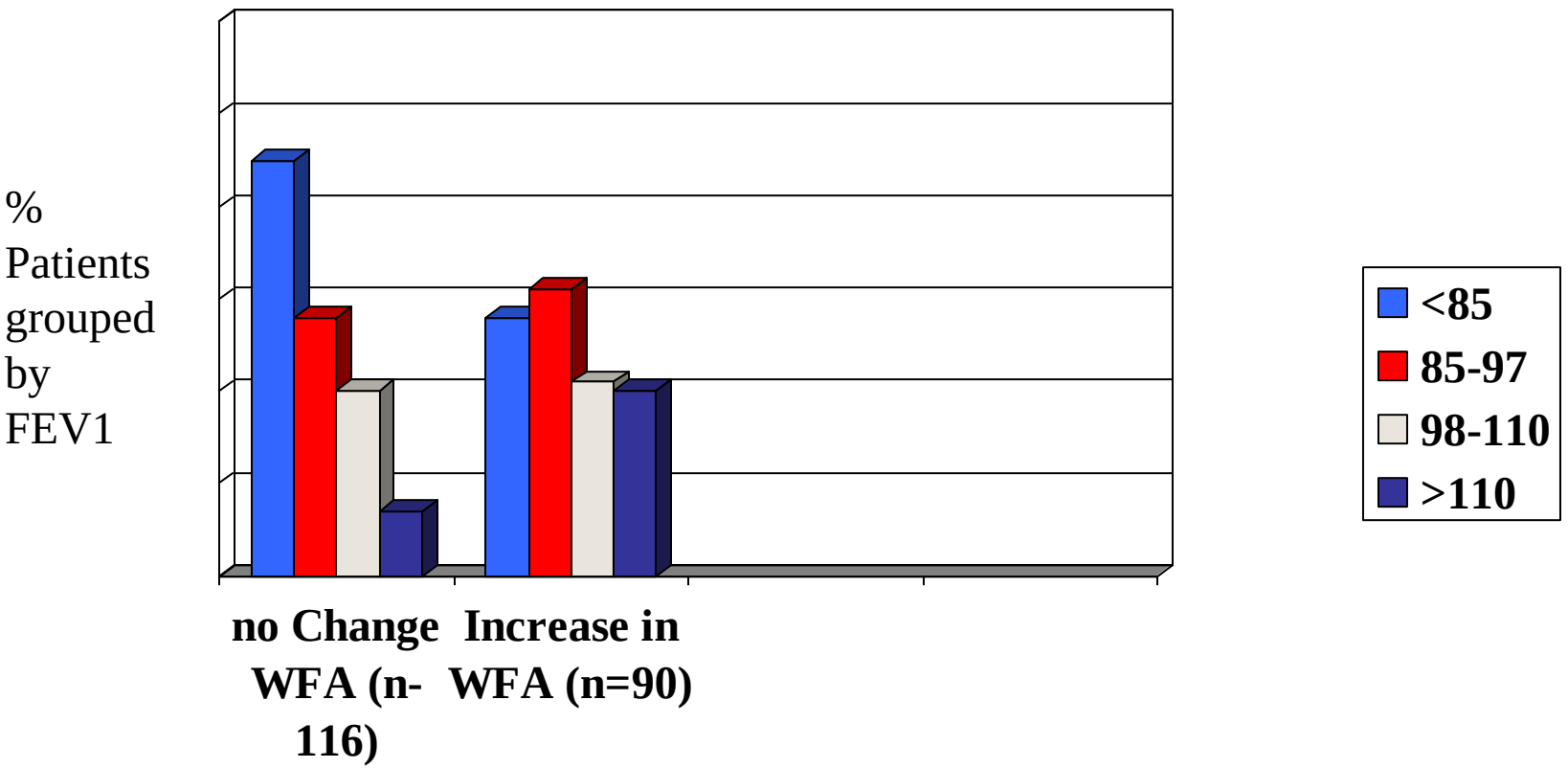
Enlarged liver

Relationship between Nutrition and CF



Konstan et. al. Pediatr Pulmonol 2000

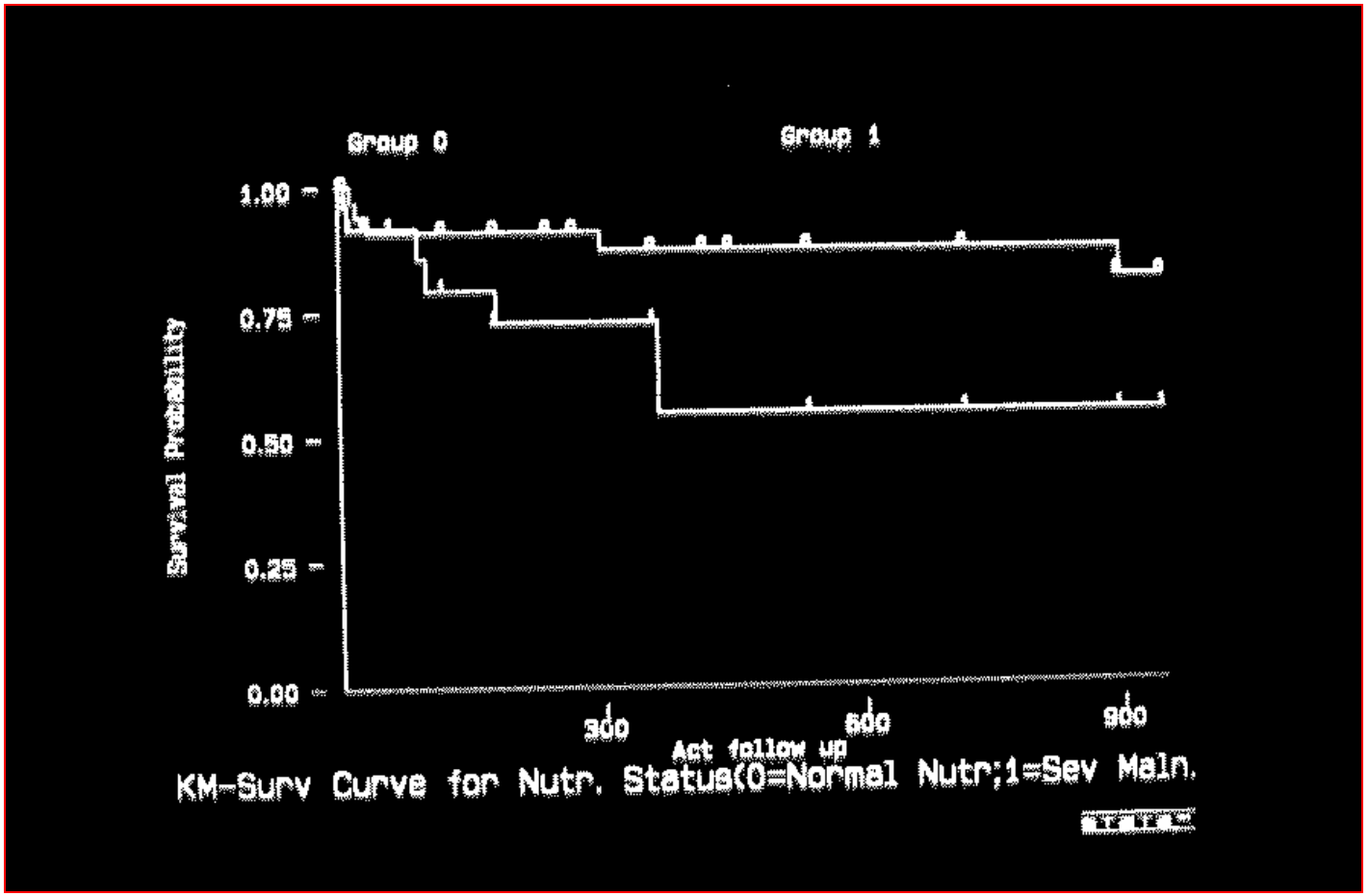
Patients who have increase in WFA from Age 3 to 6 years have higher FEV1 at age 6 year



Konstan et al, Pediatr Pulmonol 2000

Slide and data from
Dr Sushil K. Kabra
AIIMS, Delhi

Nutritional Status and Survival

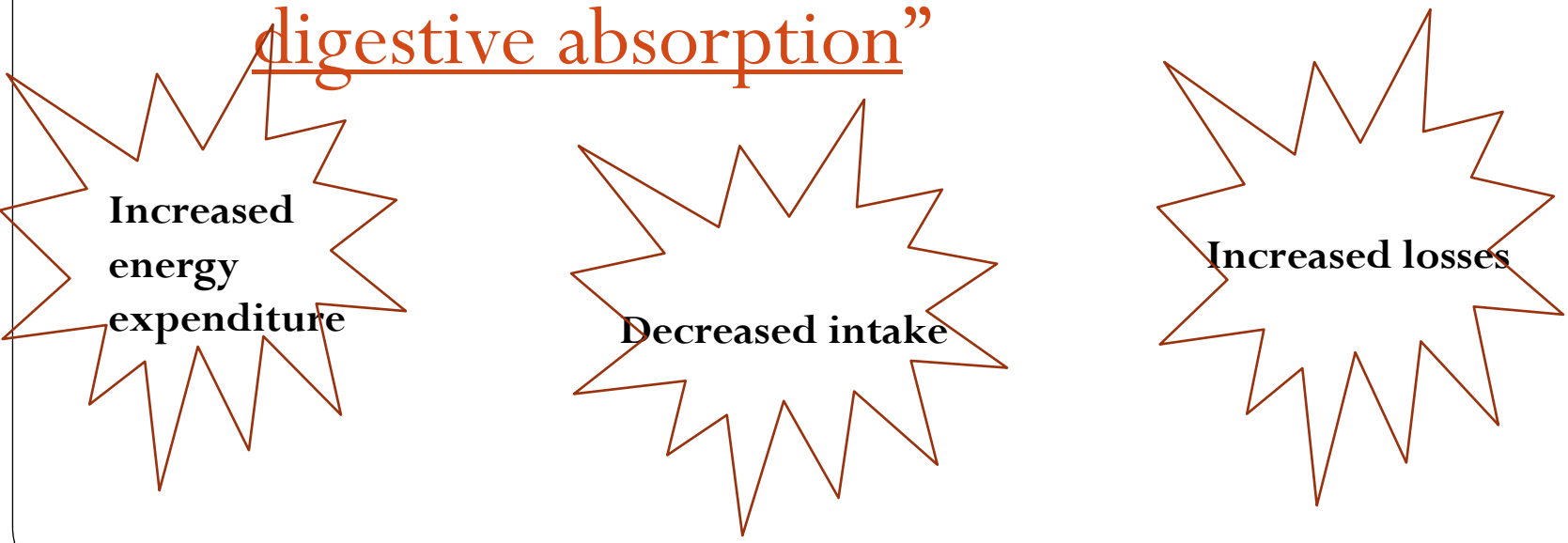


Dietary advice, enzyme supplementation and treatment of LRTI may improve the outcome of CF

Pediatric Pulmonology 1999; supplement 19: 337

Basically .....

"The individual with CF must work diligently to consume adequate energy in order to meet **increased needs** caused by the increased work of breathing and altered digestive absorption"



CF nutrition : issues

- Chronic sinusitis- altered smell and taste
- Gastroesophageal reflux, heartburn, reduced appetite
- Chronic cough, phlegm
- Increased caloric requirement due to recurrent illnesses
- Higher REE , related to pulmonary disease

- **At risk for CF related diabetes**
- **Fat malabsorption**, need **pancreatic enzyme replacement** therapy, **fat soluble vitamin** supplementation
- **CF related liver disease**, low albumin

- (Need to consider other routes of feeding? Nasogastric feeds, Gtube feeds)

So what does this mean....for the nutritionist

- Need to provide more than estimated caloric requirement (120-150% RDA)
- Need high fat diet (40% fat), fat soluble vitamins ADEK
- Need sufficient protein for growth

- Need to overcome energy deficit, promote growth and development

- Supplement salt, excessive losses in sweat.
- Provide iron, micronutrients, fatty acids
- (Pancreatic enzymes with each meal and snack)
- (Monitor sugars, screen for CF related diabetes)

Energy expenditure in CF

- **Increased REE (resting energy expenditure) in CF**
- ? Related to genotype *
- ? Related to decline in lung function/severity of lung disease**
- ? Related to gender

Energy expenditure and genotype of children with cystic fibrosis
Tomezsko JL et al. Pediatric Res 1994 Apr;35:451-60.
****** ***Resting energy expenditure and lung disease in cystic fibrosis.***
Dorlöchter L, Røksund O et al. J Cyst Fibrosis. 2002 Sep;1(3):131-6.
******* ***Differences in resting energy expenditure between male and female children with cystic fibrosis. Allen JR et al.*** *Journal of Pediatrics. Vol142, Issue 1. 2003, Pages 15–19*

CF : Infants

- Highest growth rate and needs
- May be malnourished at diagnosis, catch up growth needs

Breastfeeding or formula ?

- Breast milk lower in protein, but many benefits.
- **Breastfed for > 6 months- beneficial ***
  (anthropometric parameters, infections, hospitalizations: may protect decline of pulmonary function.
  BF should be promoted

***Benefits of breastfeeding in cystic fibrosis: a single-centre follow-up survey.** Colombo C et al. Acta Paediatr. 2007 Aug;96(8):1228-32. Epub 2007 Jun 21.*

CF infants: Elemental formula ?

- May use elemental formulas for infants with gut resection, short gut syndrome

- Results from a randomized study **failed to support the use of a hydrolyzed formula for the routine care** of infants newly diagnosed with CF.

Do infants with cystic fibrosis need a protein hydrolysate formula? A prospective, randomized, comparative study. Ellis L, Kalnins D et al. J Pediatr. 1998 Feb;132(2):270-6

CF: Infants

- Human milk fortifiers for preterms
- Medium chain triglyceride oil added to feeds

- Enzymes given with soft solid even in neonatal period !!

- Will need salt supplement !!
- Wean at appropriate age
- Control gastroesophageal reflux (worse with chronic cough)

Nutrition considerations with age

Toddlers

-variable intake
"picky eaters"

Adolescents

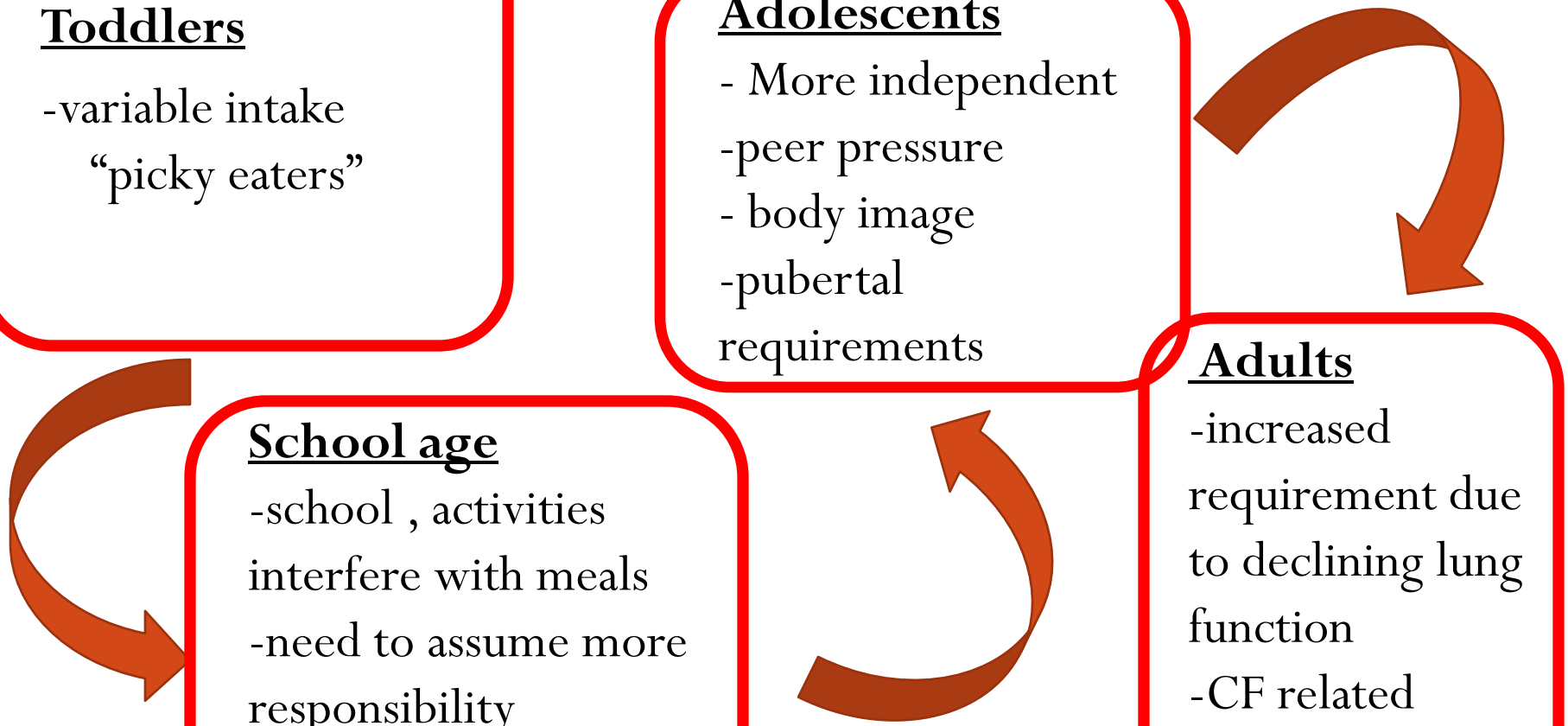
- More independent
-peer pressure
- body image
-pubertal requirements

Adults

-increased requirement due to declining lung function
-CF related diabetes
- comorbid conditions

School age

-school , activities interfere with meals
-need to assume more responsibility
-peer pressure



Dietary intake in children and adolescents with cystic fibrosis
J.W. Woestenenk et al
Clinical Nutrition (2013) 1e5- Article in press

- Recommendation for caloric intake in CF patients is 110 and 200% of the estimated average requirement (EAR) for age groups and gender, of which 35- 40% energy should be from fat. It is questionable whether the advice is met.

- 1726 Completed 3-day dietary food records of 234 CF patients (111 girls)
  and 2860 completed two non-consecutive 24-hourdietary assessments of healthy controls (1411 girls) were studied.
- The dietary intake in CF patients was compared with that of healthy controls by using independent sample t tests.

Dietary intake in children and adolescents with cystic fibrosis
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- Caloric intake in CF children varied highly with age (88-127% EAR), which is in the **lower range of the recommended 110-200% EAR.**

- CF patients had a significantly higher caloric intake than controls.

- Most CF children had fat intake of 35 energy% or more- which was significantly higher than in controls
- Consumption of saturated fat, was well above 10% of the total energy intake.

- Fat intake does generally meet recommendations, but this resulted in a **considerable consumption of saturated fat; a reduction of the latter seems appropriate.**

Oral calorie supplements for cystic fibrosis *

- **There were no significant differences between persons receiving supplements or dietary advice alone**

for change in weight, height, body mass index, z score or other indices of nutrition or growth

**** Oral calorie supplements for cystic fibrosis (Review) Smyth RL, Walters S. Cochrane Database of Systematic Reviews 2012, Issue 10.***

Oral calorie supplements for cystic fibrosis *

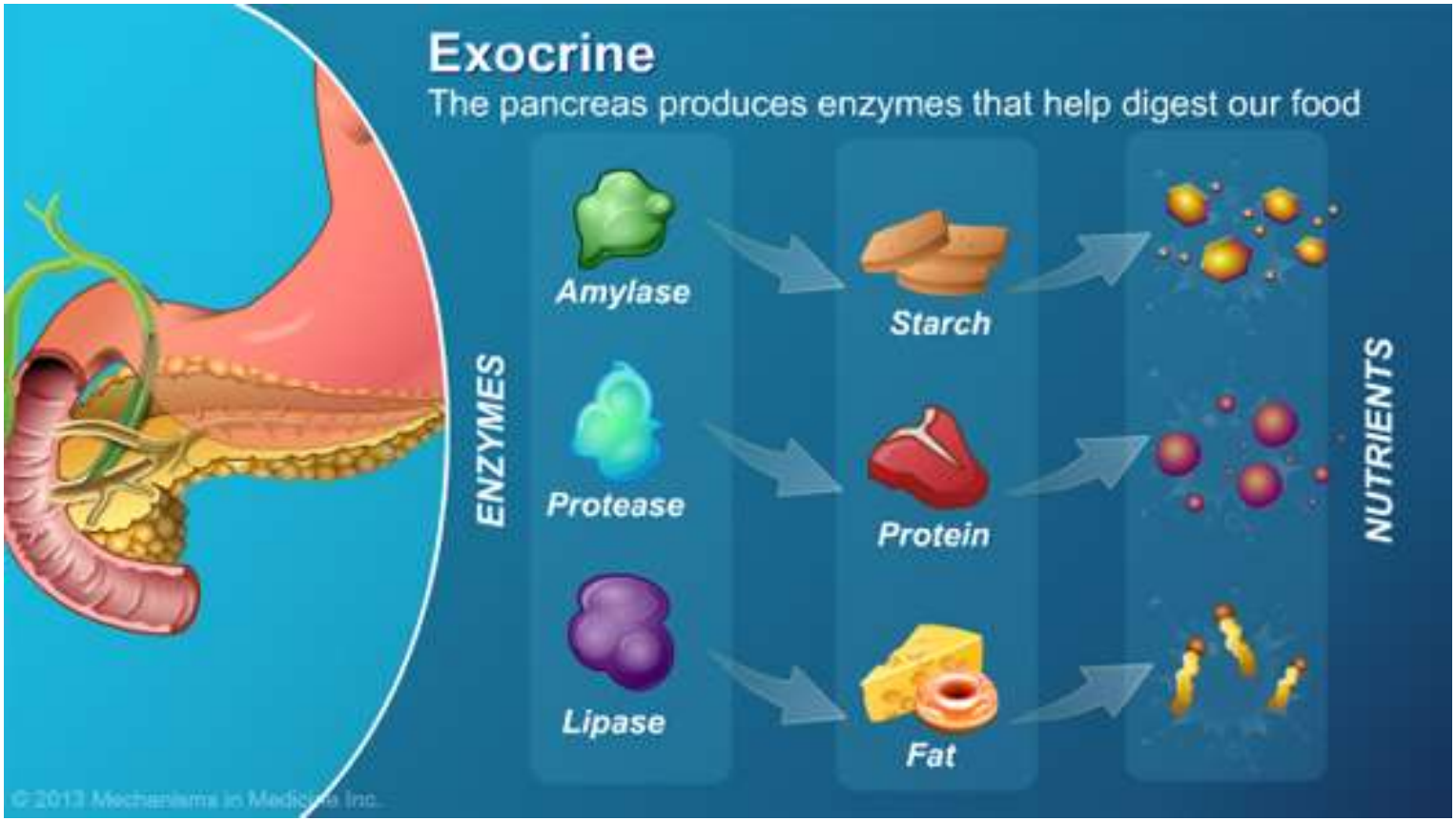
- Oral calorie supplements **do not** confer any additional benefit in the nutritional management of moderately malnourished childrenwith CF, **over and above the use of dietary advice and monitoring alone.**

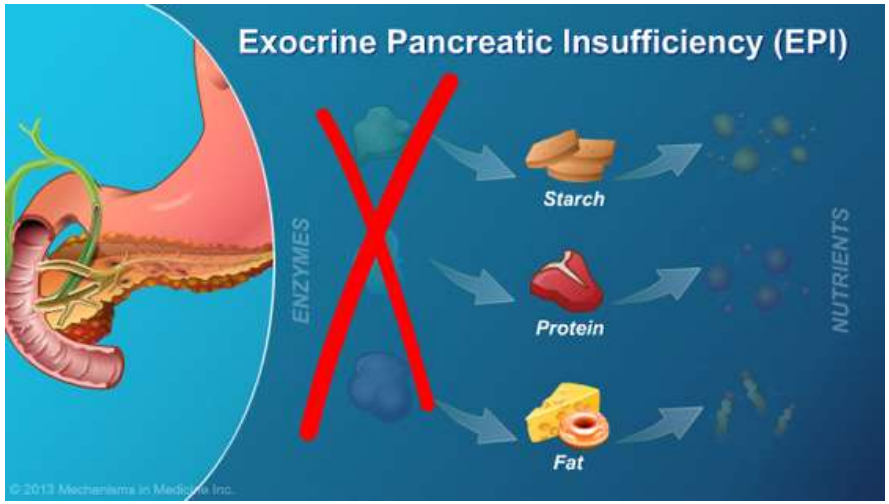
- While nutritional supplements may be used, they should not be regarded as essential.

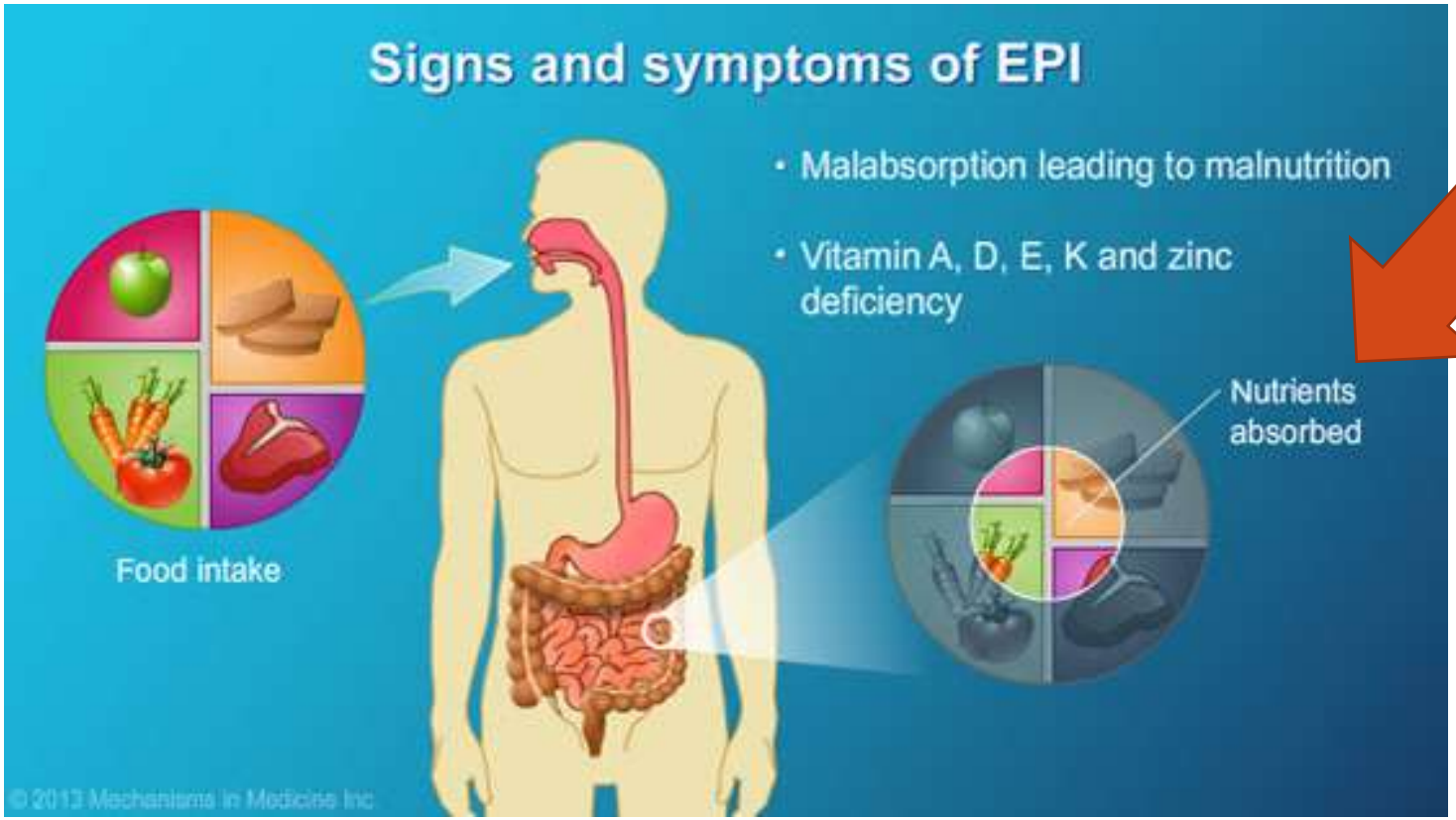
- Further randomized controlled trials are needed to establish the role of short-term oral protein energy supplements in people with CF and acute weight loss and also for the long-term nutritional management of adults with CF or advanced lung disease, or both.

**** Oral calorie supplements for cystic fibrosis (Review) Smyth RL, Walters S. Cochrane Database of Systematic Reviews 2012, Issue 10.***

Exocrine function of the pancreas




Exocrine Pancreatic Insufficiency (EPI)
ENZYMES
Starch
Protein
Fat
NUTRIENTS
© 2013 Mechanisms in Medicine Inc.


Signs and symptoms of EPI
• Malabsorption leading to malnutrition
• Vitamin A, D, E, K and zinc deficiency
Food intake
Nutrients absorbed
© 2013 Mechanisms in Medicine Inc

PERT

- Oral pancreatic enzyme replacement therapy (porcine derived lipase, amylase, protease)

- Dosage based on fat content of food, and body weight
- 500-2500 units of lipase /kg body weight per meal (1/2 this dose with snacks)

- Not to exceed 10,000 units/kg body weight lipase per day
- Ideally taken with meals

PERT (pancreatic enzyme replacement therapy)

- Produced from porcine pancreatic tissue
- Lipase, amylase, protease
- Enzymes- microspheres, enteric coated, coat dissolves at pH of 6

- Non-enteric coated powder (Viokase)
- CF patients have deficient bicarbonate secretion, increased acid production- therefore **antacids can** increase efficacy of enzymes
- CFF discourages generic enzymes because although same dose of lipase, different coating may not be biologically equivalent

Fat malabsorption in CF

- Despite advances in CF care intestinal fat malabsorption remains a persistent feature,
- Difficulty of achieving complete correction of fat malabsorption in clinical practice despite remarkable benefits resulting from exogenous pancreatic enzyme replacement therapy (PERT)

- Various defective mechanisms in CF , **abnormal, intraluminal and intracellular factors.**
- Relationship between **essential fatty acid deficiency** (EFAD) and intestinal fat transport

Mechanisms of lipid malabsorption in Cystic Fibrosis: the impact of essential fatty acids deficiency

N Peretti,V Marcil, E Drouin, E Levy Nutr Metab (Lond) 2005; 2: 11.

Fat malabsorption in CF patients on pancreatic enzymes

- Study investigating whether fat malabsorption in CF patients treated with PERT is caused by
  -insufficient lipolysis of triacylglycerols or
  - by defective intestinal uptake of long-chain fatty acids.

- Results suggest that continuing fat malabsorption in CF patients receiving PERT is not likely due to insufficient lipolytic enzyme activity,
  but rather to
  - **incomplete intraluminal solubilization** of long-chain fatty acids
  - **reduced mucosal uptake** of long-chain fatty acids, or both.

Fat malabsorption in cystic fibrosis patients receiving enzyme replacement therapy is due to impaired intestinal uptake of long-chain fatty acids.
Kalivianakis M et al .Am J Clin Nutr 1999 Jan;69(1):127-34.

Role of medium chain triglycerides in CF

- **Report in 1976- Article in German Wien KlinWochenschr. 1976 Sep 17;88(17):557-61. [Long-term use of medium chain triglycerides in cystic fibrosis(author's transl)].Widhalm K, Götz M.**

- 15 CF children (aged 4 to 17 years) and persistent failure to thrive supplemented on an out-patient basis by a daily oral intake of 35 g of medium chain triglycerides (MCT) fat.

- Followup 6 months after initiation of the MCT diet
  - frequency of the bowel movements was reduced and abdominal discomfort disappeared but no weight gain was observed.

- No significant changes in either serum cholesterol or serum triglycerides were detected over the 6-month period.
- No clinical signs of an essential fatty acid deficiency

MCT

- MCT digestion starts in the stomach (by gastric lipase)in addition to pancreatic and intestinal lipases unlike LCT digested only by pancreatic lipase.

- Rapidly absorbed by enterocytes
  Directly reaches the liver via hepatic portal vein
  unlike LCT which undergo lymphatic circulation.

- (Additional benefit in lung disease: MCT –being fat source has low respiratory quotient compared to carbohydrates, poses least load on the respiratory system)

Effect of supplementing medium chain triglycerides with linoleic acid-rich monoglycerides on severely disturbed serum lipid fatty acid patterns in patients with cystic fibrosis.

Ann Nutr Metab. 1985;29(4):239-45. Christophe A et. Al.

7 CF patients with fatty acid composition indicating essential fatty acid deficiency, were given a mixture of medium chain triglycerides (MCTs) with linoleic acid-rich monoglycerides (LAMs) as food fat (about 1-1.25 g/kg body weight/day).

Treatment resulted in a significant increase of the previously reduced fraction of linoleic acid in all lipid classes.

Thus, supplementing a MCT-containing diet with LAMs in cystic fibrosis patients results in a considerable **amelioration of the previously disturbed fatty acid composition (FAC) of the major serum lipid classes.**

Energy supplements rich in linoleic acid improve body weight and essential fatty acid status of cystic fibrosis patients. J Pediatr Gastroenterol Nutr. 2000 Oct;31(4):418-23.
Steinkamp G et al

The effects of an oral energy supplement rich in linoleic acid in CF

- In contrast to the control group (dietary counselling alone), the patients with supplemented diets achieved significant increases of
  - energy
  - weight for height
  - body fat
- as well as the initially low values of plasma phospholipid linoleic acid and its main metabolite arachidonic acid

- CF Patients with cystic fibrosis with low body weight and poor EFA status benefit from EFA-rich energy supplements and can synthesize arachidonic acid from the precursor linoleic acid.

Omega 3 and Omega 6 fatty acids

- Diet rich in fat (including animal fat) has omega-6 fatty acids

which may adversely affect CF patients by encouraging- inflammation in the lungs.

- In contrast, omega-3 fats appear to be of clinical benefit in CF. Reduction of sputum, improved lung function, a decrease in inflammation, and a decreased need for antibiotics have been observed in patients who have taken omega-3 fatty acid supplements.

  Increasing intake of plant sources of omega-3 fats (e.g., flax seed and flax oil) and monounsaturated fats (e.g., olive oil) has been suggested as an approach to improving fatty acid nutrition in CF patients.

Fat soluble vitamins (ADEK) in CF

- Fat soluble vitamin deficiency recognized in CF
- PERT does not always correct this, hence oral supplementation needed

Cochrane reviews on CF and supplementation of:

- Vit A : no randomized trials (2012)
- Vit D : no evidence of benefit or harm in the limited number of small-sized published trials (2012)
- Vit K: Evidence from RCTs on benefits of routine vitamin K supplementation for people with CF is currently weak (2012)
- Vit E: (protocol alone, no review, 2012)

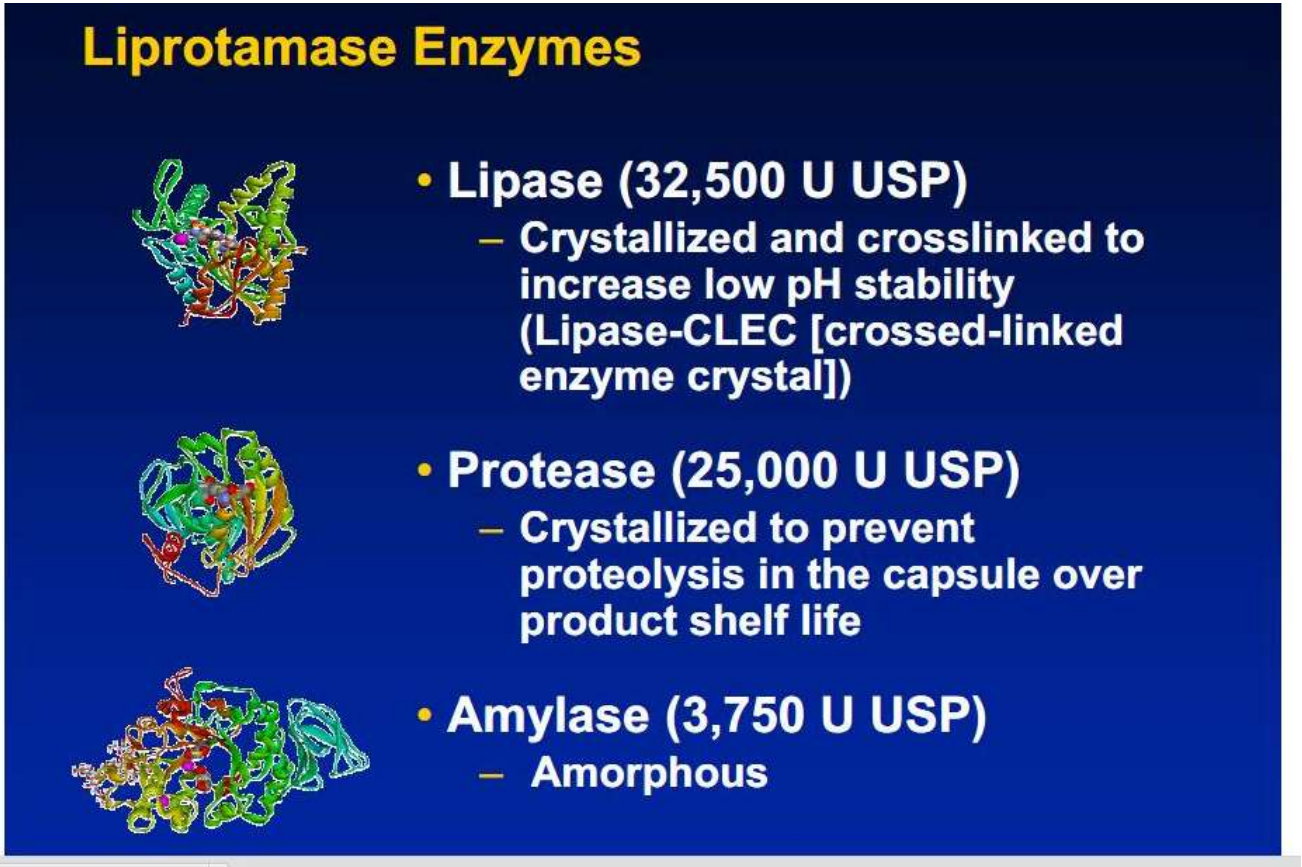
- Recommend –follow current guidelines /expert consemsus
- Annual testing : serum vitamin levels, A, D, E, and Prothrombin time (PT) for K

PERT- update

- In 2010, the FDA required manufacturers of PERT to have approval for marketing, rescinding the distribution of PERT that had been available for decades without definitive studies of efficacy and safety.
- All preparations tests demonstrated superiority over placebo-controlled portions of the clinical trials.
- Side-effects no different compared with placebo.
- **Additional PERTs are being evaluated including a nonporcine preparation which may be available in the future.**
- Some patient variability to response continues, so clinicians need to continue to titrate dose and preparations based on weight gain and patient response.

Curr Opin Pediatr. 2011 Oct;23(5):541-4 **Pancreatic enzyme supplementation.** Wier HA, Kuhn RJ.

New PERT-
Lipoprotamase – nonporcine PERT



New PERT- Lipoprotamase

- **International phase III trial of liprotamase efficacy and safety in pancreatic-insufficient cystic fibrosis patients.** J Cyst Fibros. 2011 Dec;10(6):443-52. Borowitz D, Stevens C, Brettman LR, Campion M, Chatfield B, Cipolli M; Liprotamase 726 Study Group.

- **Liprotamase long-term safety and support of nutritional status in pancreatic-insufficient cystic fibrosis.**Borowitz D, Stevens C, Brettman LR, Campion M, Wilschanski M, Thompson H; Liprotamase 767 Study Group. J Pediatr Gastroenterol Nutr. 2012 Feb;54(2):248-57.

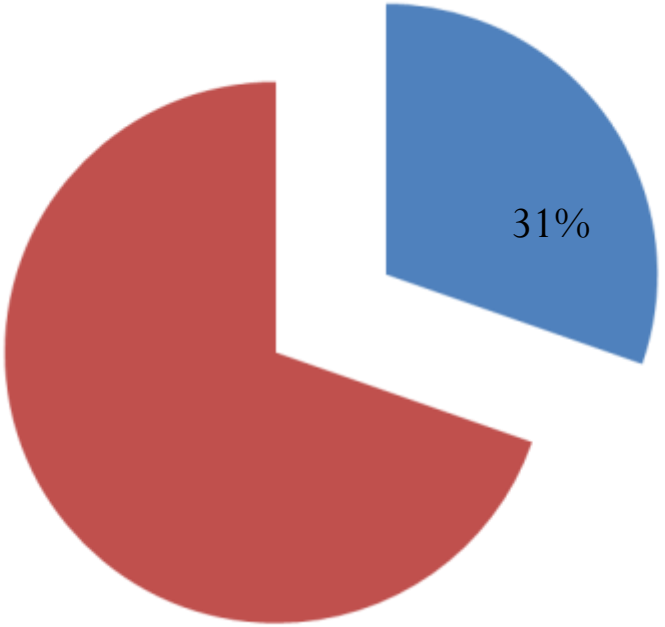
Zinc deficiency in CF

- Poor absorption , and increased endogenous fecal zinc losses
- Zinc deficiency can affect Vitamin A absorption, transport, utilization
- Normal children- supplement 1mg/kg/day upto 10-15 mg/day
- *No specific dosing recommendations for CF)

Slide and data from
Dr Sushil K. Kabra
AIIMS, Delhi

CF in Indian Children Micronutrient Deficiency

Lab parameter	Total
Serum zinc <70ppm	**17(31.48%)**
Serum calcium <9 mg/dl	5 (9%)



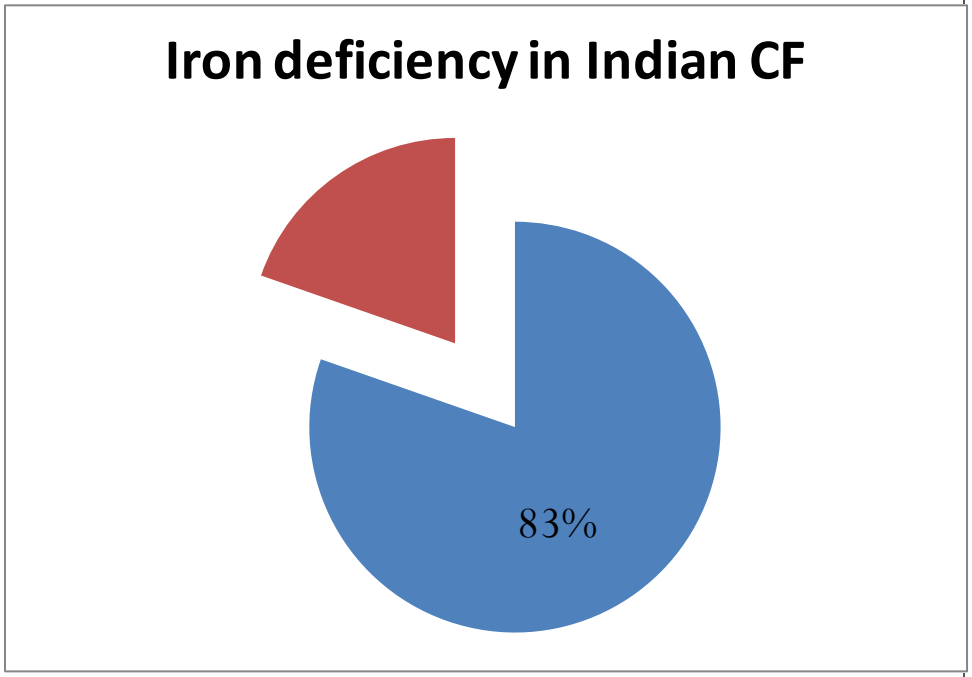
Many Indian CF Children are deficient in Zinc

Need to study effect of zinc supplement on morbidity

Iron Profile of Indian CF Patients

Slide and data from
Dr Sushil K. Kabra
AIIMS, Delhi

Lab parameter	Total
MCV <85	32 (59%)
Hb<10	6(11.11%)
Serum iron <75	**45(83.33%)**
% saturation <20	**42(77.78%)**
Serum iron mean Median	47.65±15.34 42



Majority of children with CF are deficient in iron and may need iron supplementation

CF related diabetes

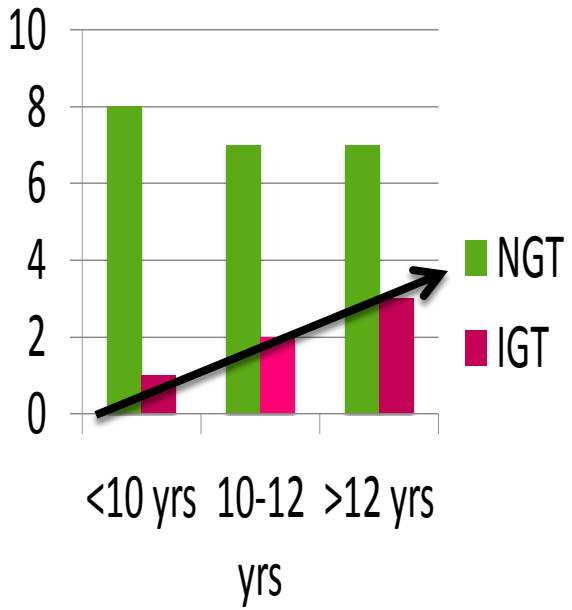
- Increasing incidence with increasing age
- Usually associated with a decline in lung function
- Insulin deficiency- pancreatic endocrine insufficiency
  Different entity than Type I and Type II DM

- Ketoacidosis is rare
- Not associated with macrovascular disease as Type I DM
- Therefore fat content of diet should not be restricted, and may need to be as high as 40%
- Avoid excessive carbohydrates

Impaired glucose Tolerance Test in Children with CF

Slide and data from Dr Sushil K. Kabra AIIMS, Delhi

Age group (Number of patients) (N 28)	Abnormal GT number (%)
<10 yrs (9)	1 (11)
10-12 yrs (9)	2(22)
>12 yrs (10)	3(30)



Complementary therapies in CF

- Vitamin A, vitamin C, vitamin E
- Zinc
- Omega 3 fatty acids, docosahexaenoic acid (DHA)
- Garlic
- Ginseng, and
- Curcumin.

J Pharm Pract. *2013 Feb;26(1):14-7.*
Complementary therapies in cystic fibrosis: nutritional supplements and herbal products.
Braga SF, Almgren MM.

Cucurmin

- Turmeric is a spice derived from the rhizomes of *Curcuma longa*, a member of the ginger family.
- Curcuminoids are polyphenolic compounds that give turmeric its yellow color
- Curcumin is the principal curcuminoid in turmeric.

Cucurmin

- Mechanisms implicated in inhibition of tumorigenesis: diverse and appear to involve a combination of antiinflammatory, antioxidant, immunomodulatory, proapoptotic, and antiangiogenic properties via pleiotropic effects on genes and cell-signaling pathways at multiple levels

- (The potentially adverse sequelae of curcumin's effects on proapoptotic genes, particularly p53, represent a cause for current debate)

Antioxid Redox Signal. *2008 Mar;10(3):511-45.*
Curcumin: preventive and therapeutic properties in laboratory studies and clinical trials.
***Strimpakos AS*, *Sharma RA*.**

Curcumin and CF

- A study done jointly at Yale University and the Hospital for Sick Children in Toronto, showed that curcumin corrects the DeltaF508 CFTR physiological defect in mice.

- Clinical benefits also were demonstrated, with CF mice treated with curcumin having a better survival rate than those not treated.

- Until the safety and efficacy of curcumin in individuals with cystic fibrosis has been evaluated in clinical trials, the Cystic Fibrosis Foundation **does not recommend the use of curcumin as a therapy for cystic fibrosis.**

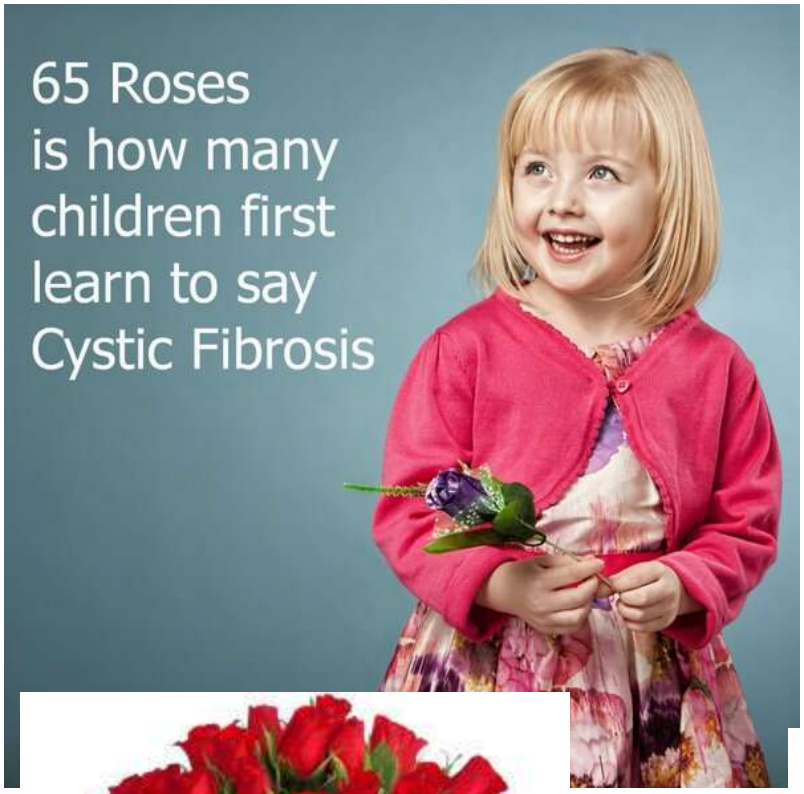
Nutrition therapy in CF

Overcome the energy deficit and promote normal growth and development for CF patients

- **Unrestricted diet**
  - **High fat, high protein diet**
  - **Enteral feeds for moderate-severe malnutrition**
- **Pancreatic enzyme supplements**
- **Fat soluble vitamins -ADEK**
- **Water soluble vitamins, zinc, iron, essential fatty acids**
- **Complementary therapies**

Nutrition in CF

- Medical management of CF is multifaceted
- **Role of nutrition in improving mortality has been established.**
- **Early identification of nutrition issues with appropriate intervention**
  plays a vital role
  in pulmonary health, and
  is key to longevity.



"65 roses"

Did You Know?

Cystic fibrosis is sometimes called "65 roses." The nickname came from a little boy who overheard his mom talking about the condition on the phone. He thought that each time his mom said "cystic fibrosis," she was talking about 65 roses.

Table 2
Definitions of Nutrition Status in Patients with Cystic Fibrosis (13)

Age Group	*At Risk*	*Nutritional Failure*
0–2 years old	Weight for length 10%–25%	Height Percentile <5%, or weight for length <10% or IBW <90%
2–20 years	BMI percentile 10th–25th	BMI percentile <10% or IBW <90%
Adults	BMI 19–20	BMI <19 or percent IBW <90%

Table 4
Dosing Pancreatic Enzymes (24)

Age Group	*Dose*	*Adjusting Dose*
Infants	2000–4000 Units lipase/120 ml formula or with each nursing OR 450–900 units lipase/gram of fat	Increase by 2000–2500 Units lipase per feed as volume increases or if symptoms of malabsorption return
Children <4 years	1,000–2,000 Units lipase/kg/meal OR 500–4,000 Units lipase/gm fat	Snacks: 1/2 meal dose Compare U lipase per fat gram when weight dose appears above range.
Adults and children >4	500–2000 Units lipase/kg/meal OR 500–4,000 Units lipase/gm fat	Snacks: 1/2 meal dose Compare U lipase per fat gram when weight dose appears above range.

Note:
- Doses of lipase greater than 2500 units/kg/meal (10,000 units/kg/d) are not recommended (23).
- >6,000 units lipase/kg/meal has been associated with colonic strictures in children <12 years (23, 24).

Goodin, B. PRACTICAL GASTROENTEROLOGY ,MAY 2005

Table 8
Vitamin Recommendations for Cystic Fibrosis (4,15)

*Age**	*Vit A (IU)*	*Vit E (IU)*[1]	*Vit D (IU)*	*Vit K (mcg)*
>8 years	5,000–10,000	200–400	400–800[2]	300–500
>18 years	10,000	400–800	400–800[2]	300–500
To correct deficiencies	10,000–20,000	400–12,000	800–1600[2] 2–4 mg/kg/d[3]	5–10 mg/week or daily[4]

[1] d-α-tocopherol
[2] D_2 or D_3
[3] Calcifediol (25-OHD)
[4] Frequency of supplementation is dependent on response to therapy.

Biochemical Testing:
Vitamin E—Serum α tocopherol
Vitamin D—Serum 25-OHD
Vitamin A—Serum retinol, retinol binding protein
- Monitor serum retinyl esters – elevation indicates toxicity

Vitamin K - PIVKA-II level or prothrombin time

*Refer to reference 15 for vitamin recommendations for children <8 years.

Goodin, B. PRACTICAL GASTROENTEROLOGY ,MAY 2005

Table 9.
Vitamin Products Specific to Cystic Fibrosis

Product	*Vitamin A IU*	*Vitamin D IU*	*Vitamin E IU*	*Vitamin K (mcg)*	*Availability*	*Cost (CF Services Pharmacy) (800) 541-4959*
CF Foundation Recommendations	5,000–10,000	400–800	200–800	300–500		
ADEK Chewables	9,000	400	150	150	Rx CF Services Pharmacy Local pharmacies	$21.95/60
Vitamax Chewables	5,000	400	200	150	Rx CF Services Pharmacy Local pharmacies	$12.95/90
ABDEK Soft Gel Capsules	9,000	400 800/chewable tablet	200	500 600/chewable tablet	Rx CF Services Local pharmacies	$18.95/90 gelcaps $29.95/90 chewables

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Table 14
Nutrition Management of Cystic Fibrosis Related Diabetes

1. Maintain high calorie intake with both simple and complex carbohydrates
2. Cover all simple carbohydrates with insulin
3. Maintain high fat diet (40%) for weight maintenance
4. Restrict sugary beverages unless they are counted as part of the carbohydrates and covered appropriately with insulin

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Special situations

- Puberty
- Pregnancy
- Post surgical
- Post-transplant

Cochrane Database Syst Rev. 2012 Dec 12;12:CD001198. doi: 10.1002/14651858.CD001198.pub3.

Enteral tube feeding for cystic fibrosis.

Conway S, Morton A, Wolfe S.

- Supplemental enteral tube feeding is widely used throughout the world to improve nutritional status in people with cystic fibrosis. The methods mostly used, nasogastric or gastrostomy feeding, are expensive and may have a negative effect on self-esteem and body image. Reported use of enteral tube feeding suggests that it results in nutritional and respiratory improvement; but, efficacy has not been fully assessed by randomised controlled trials. It is acknowledged, however, that performing a randomised controlled trial would be difficult due to the ethics of withholding an intervention in a group of patients whose nutritional status necessitates it.