

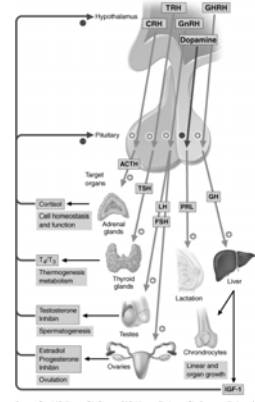
# Pituitary Tumors: Evaluation and Management

Joseph J. Pinzone, MD, MBA

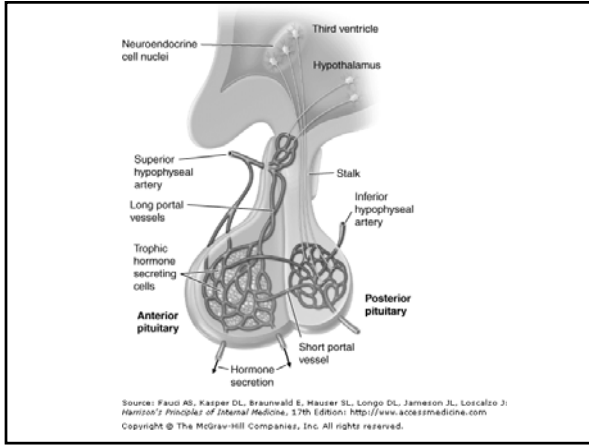
Assistant Professor of Medicine  
The Ohio State University Medical Center

## Anterior Pituitary Hormone Feedback

To assess pituitary function  
measure both pituitary and  
end-organ hormone levels



Source: Fauci AS, Kasper DL, Braunwald E, Hauser SL, Longo DL, Jameson JL, Loscalzo J: Harrison's Principles of Internal Medicine, 17th Edition. <http://www.accessmedicine.com>. Copyright © The McGraw-Hill Companies, Inc. All rights reserved.



Source: Fauci AS, Kasper DL, Braunwald E, Hauser SL, Longo DL, Jameson JL, Loscalzo J: Harrison's Principles of Internal Medicine, 17th Edition. <http://www.accessmedicine.com>. Copyright © The McGraw-Hill Companies, Inc. All rights reserved.

## Pituitary Pathology

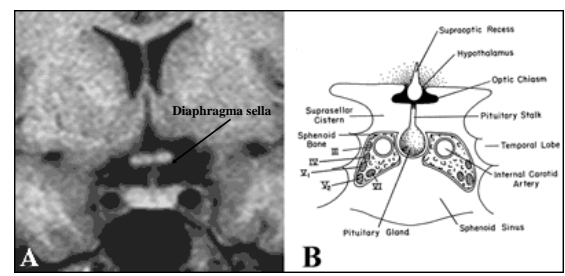
### Functional – Hormonal Testing

### Structural – Imaging

## Pituitary Pathology

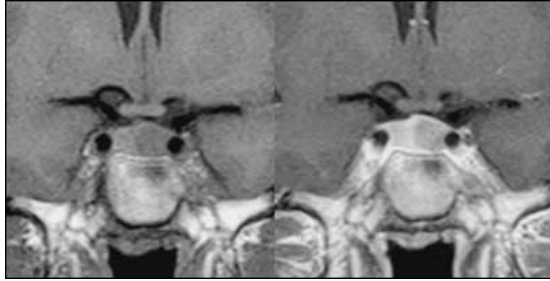
- Neoplasms
- Functional
- Pharmacological
- Inflammatory
- Infectious
- Infiltrative
- Trauma

## Normal Pituitary MRI



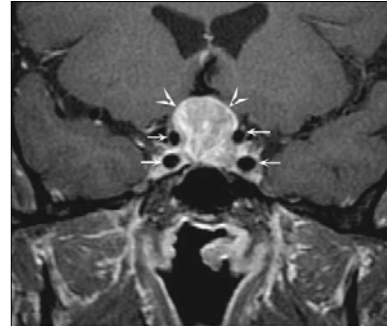
<http://www.endotext.org/neuroendo/neuroendo3b/figures3b/figure6.gif>

## Pituitary Microadenoma

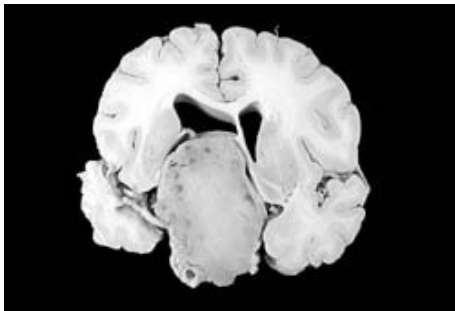


<http://www.endotext.org/neuroendo/neuroendo4/neuroendoframe4.htm>

## Pituitary Macroadenoma

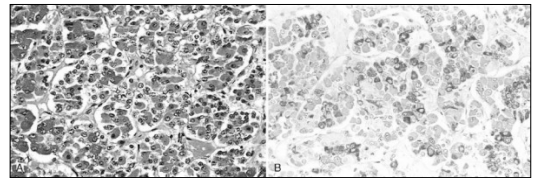


## Giant Pituitary Adenoma



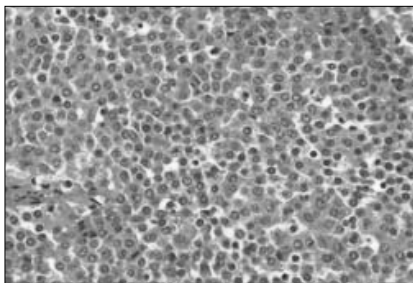
Kumar: Robbins and Cotran: Pathologic Basis of Disease, 7th ed., 2005 Saunders

## Normal Pituitary



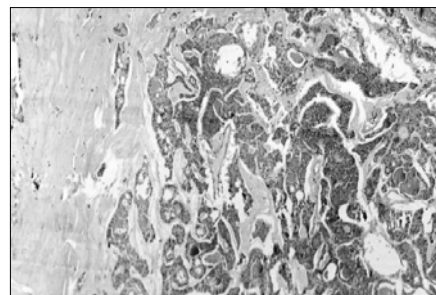
Kumar: Robbins and Cotran: Pathologic Basis of Disease, 7th ed., 2005 Saunders

## Pituitary Adenoma



Kumar: Robbins and Cotran: Pathologic Basis of Disease, 7th ed., 2005 Saunders

## Pituitary Carcinoma



<http://erl.pathology.iupui.edu/C604/IMAGES/ENDO/3CA10B.JPG>

# Incidentaloma

## Prevalence of Pituitary Pathology

Study (Reference)	Pituitaries Examined	Adenomas Found	Frequency	Macroadenomas Found	Stain for Prolactin
	n	n	% (95% CI)	n	% (95% CI)
Suzman (18)	260	23	8.8 (5.4 to 12.2)		
Cordella (19)	1000	225	22.5 (19.9 to 25.1)	0	
Sommers (20)	400	26	6.5 (4.1 to 8.9)	0	
McCormick and Halmi (21)	1600	145	9.1 (7.7 to 10.5)	0	
Kovacs et al. (22)	152	22	14.5 (8.9 to 20.1)	2	53 (28 to 77)
Lambolt (23)	100	14	14.0 (7.2 to 20.8)	0	
Mosca et al. (24)	100	24	24.0 (15.8 to 32.4)	0	20 (4 to 48)
Burrows et al. (25)	120	32	26.7 (17.8 to 35.6)	0	41 (26 to 58)
Parent et al. (26)	300	42	8.4 (6.0 to 10.8)	1	
Mohr et al. (27)	205	3	1.5 (0.2 to 3.2)	0	
Schwendinger and Watzek (28)	5100	485	9.5 (8.7 to 10.3)	0	
Coulter et al. (29)	100	10	10.0 (4.1 to 15.9)	0	60 (26 to 88)
Chambers et al. (3)	100	14	14.0 (7.2 to 20.8)	0	

Total 9737 1065 11.4%

Molitch ME and Russell EJ Ann Int Med 1990; 112:925-931

## Incidentaloma: Natural History

	Decrease	Increase	Unchanged
Number of patients	29 (12.0%)	30 (12.4%)	180 (74.4%)
M:F	16:13	16:14	70:110
Mean age (years)	42.1	54.7	49.9
Microadenoma	7	15	57
Macroadenoma	22	20	125
Average time to change	31.3 months (2-78 months)	45.5 months (8-173 months)	—
Non-functioning adenoma (n = 115)*	11 (9.6%)	23 (20.0%)	83 (72.2%)
Rathke's cyst (n = 94)**	15 (15.9%)	9 (9.3%)	72 (76.5%)
Cyst (n = 10)	0	1	9
Others (n = 20)	3	1	16

86.4% decreased or remained unchanged

Sanno N, et al Eur J Endocrinol 2003; 149:123-127

## Incidentaloma Management

- Obtain an MRI
- < 10 mm
  - Screen clinically for Cushing's and acromegaly
  - Check prolactin
  - Watchful waiting or treat hyperprolactinemia if needed
  - Consider full hormonal workup
- ≥ 10 mm
  - Check prolactin
  - Screen clinically and biochemically for Cushing's and acromegaly
  - Screen biochemically for hypopituitarism
  - Check visual fields
  - Surgery

# Prolactinoma

## Prolactin in Pregnancy and Lactation

- Pituitary gland size doubles during pregnancy
- PRL rises to a mean of 207 ng/mL during pregnancy<sup>1</sup>
- In the absence of suckling PRL normalizes in 7 days
- Suckling increases mean PRL level 8.5-fold<sup>2</sup>
- PRL rises with each suckling episode
- Mean post-partum PRL levels - 164 ng/mL 2-4 wks  
130 ng/mL 5-14 wks  
77 ng/mL 15-24 wks

1. Tyson JE, et al Am J Obstet Gynecol 1972; 113:14-20.  
2. Noel GL, et al J Clin Endocrinol Metab 1974; 38:413-423.

## Prolactinoma Diagnosis

- Premenopausal Women
  - Oligo/Amenorrhea
  - Galactorrhea
  - Mass Effect
- Men<sup>1</sup>
  - Diminished Libido 83%
  - Adiposity 69%
  - Apathy 63%
  - Headache 63%
- Postmenopausal Women
  - Mass Effect
  - Galactorrhea

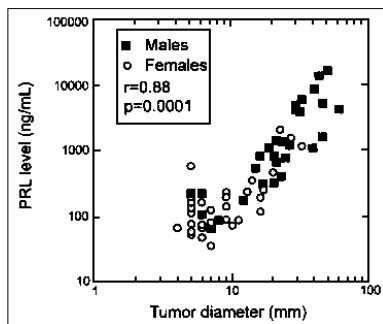
1. Cohen LM, et al Psychosomatics 1984; 25:925-928.

## Prolactinoma Diagnosis

Hyperprolactinemia  
Women > 20 ng/mL  
Men > 15 ng/mL

Imaging  
Normal Imaging  
Microadenoma  
Macroadenoma

## Prolactinoma Level Correlates with Tumor Size



## Physiological Prolactin Elevation

- Exercise
- Meals
- Coitus
- Nipple Stimulation
- Acute Stress

## Pathological Prolactin Elevation

- Prolactinoma
- Non-functioning adenoma – “stalk effect”
- Acromegaly – co-secretor
- Other hypothalamic/pituitary pathology
- Medication

## Medication-induced Prolactin Elevation

- Neuroleptics and Dopamine Receptor Blockers
- Dopamine Synthesis Inhibitors
- Catecholamine Depletion
- Cholinergic Agonists
- Antihypertensives
- H<sub>2</sub> Receptor Blockers
- Estrogens and Oral Contraceptives
- Anticonvulsants
- Anesthetics

## Prolactinoma Treatment Options

- Watchful Waiting
- Dopamine Agonist Therapy
  - Cabergoline (Dostinex®)
  - Bromocriptine (Parlodel®)
- Surgery
- Radiotherapy

## When can I use watchful waiting?

- Must be a microadenoma
- Premenopausal Women
  - Normal menses
- Postmenopausal Women
  - Appropriate LH elevation
  - Normal bone density
- Men
  - Normal testosterone
  - Normal bone density

## Natural History of Untreated Microprolactinomas

Author	n	Mean Duration of Observation (yrs)	Serum Prolactin Level		
			↔	↓	↑
March, et al <sup>1</sup>	43	4	38	3	2
von Werder, et al <sup>2</sup>	30	3 – 6	26	2	2
Koppelman, et al <sup>3</sup>	20	5.3	2	14	4
Martin, et al <sup>4</sup>	41	5.5	11	23	7
Sisam, et al <sup>5</sup>	38	4.2	5	21	12
<b>Total</b>	<b>172</b>	<b>4.7</b>	<b>82</b>	<b>63</b>	<b>27</b>

84.3% decreased or remained unchanged

1. March CM, et al. Am J Obstet Gynecol 1981; 139:835-844  
 2. von Werder K, et al. Prolactin and Prolactinomas. New York: Raven Press, 1983: 415-429  
 3. Koppelman MC, et al. Ann Intern Med 1984; 100:115-121  
 4. Martin TL, et al. J Clin Endocrinol Metab 1985; 60:855-858  
 5. Sisam DA, et al. Fertill Steril 1987; 48:67-71

## Dopamine Agonists as Primary Therapy

Clinical and biochemical characteristics	Microprolactinomas (n = 12)	Macroprolactinomas (n = 34)
Age at diagnosis (yr, median [range])	49 (38-72)	46 (18-74)
Diminished libido (no. (%))	7 (58)	21 (62)
Impotence (no. (%))	9 (75)	29 (85)
Headache (no. (%)) <sup>a</sup>	0 (0)	14 (41)
Visual field abnormalities (no. (%)) <sup>a</sup>	0 (0)	11 (32)
Extracellar extension (no. (%)) <sup>a</sup>	2 (17)	23 (68)
Testosterone deficiency (<200 ng/dL, no. (%))	2 (17)	14 (41)
PRL (ng/mL, median [range]) <sup>a</sup>	99 (16-385)	1415 (387-67,900)

Mean Prolactin Level      99 (16-385)      1415 (387-67,900)

Clinical and biochemical characteristics	Microprolactinomas (n = 20)	Macroprolactinomas (n = 58)
Follow-up (yr, median [range])	4.0 (0.5-7.7)	4.4 (0.1-11.5)
Diminished libido (no. (%))	4 (20)	11 (19)
Impotence (no. (%))	6 (30)	13 (22)
Headache (no. (%))	0 (0)	4 (7)
Visual field abnormalities (no. (%))	0 (0)	3 (5)
Reduction in tumor mass (no. (%))	18 (90)	52 (90)
Normal testosterone (no. (%))	18 (90)	52 (90)
Normal PRL (<15 ng/mL, no. (%))	18 (90)	52 (90)
PRL decrease (median % [range]) <sup>a</sup>	91.1 (81.1-99.9)	99.8 (81.3-99.9)

Normal Prolactin Level      83%      79%

Pinzone JJ, et al J Clin Endocrinol Metab 2000; 85:3053-3057

## Non-functioning Pituitary Macroadenomas

## Pituitary Tumor Mass Effects

### Common

- Pituitary
  - Hypopituitarism
- Optic Chiasm
  - Bitemporal hemianopsia
- Central
  - Headache

### Less Common

- Cavernous Sinus
  - Ophthalmoplegia
- Frontal Lobe
  - Personality Disorders
- Temporal Lobe
  - Seizures
- Hypothalamus
  - Diabetes Insipidus

## Paris Seen Normally



[http://en.wikipedia.org/wiki/Visual\\_field](http://en.wikipedia.org/wiki/Visual_field)

## Paris with Bitemporal Hemianopsia



[http://en.wikipedia.org/wiki/Visual\\_field](http://en.wikipedia.org/wiki/Visual_field)

## Management of Non-functioning Macroadenomas

- Check for hypopituitarism – replace deficits pre-op
- Check prolactin – “stalk level” < 150 ng/mL
- Screen biochemically for Cushing’s and acromegaly
- Pre-treat some with glucocorticoids prior to surgery
- Treat all with glucocorticoids intra- and post-op
- Monitor for DI or delayed SIADH post-op
- Send home on hydrocortisone  
We use 20mg po qam and 10mg po q4pm

## Results of Surgery

- Depends on surgeon, tumor size, location
- Visual fields improve in 70-87%<sup>1,2,3</sup>
- Normalization of vision in 25%<sup>2</sup>
- Endocrine function improves in 27%<sup>2,3,4</sup>
- Normalization of endocrine function in 15%<sup>2,3,4</sup>
- Normal pituitary function preserved in 70%<sup>4</sup>

1. Laws ER, Jane JA Clinical Neurosurgery. 2001;48:306-319.
2. Colao A, et al. J Endocrinol Invest 1998;21:284-290.
3. Kurosaki M, et al. Neurosurgery 2000;47:843-848
4. Laws ER, Jr. Clin Neurosurg 2001;48:306-19.

## Results of Surgery

- Normal menstruation preserved in 90%<sup>1</sup>
- Menstruation restored in 56%<sup>1</sup>
- New Hormonal deficits occur in up to 40%<sup>2,3,4</sup>

1. Webb SM, et al. J Clin Endocrinol Metab 1999;84:3696-700.
2. Colao A, et al. J Endocrinol Invest 1998;21:284-290.
3. Kurosaki M, et al. Neurosurgery 2000;47:843-848
4. Laws ER, Jr. Clin Neurosurg 2001;48:306-19.

## Results of Surgery

- Immediate post-op polyuria in 30% but persists in only 3 – 10%<sup>1,2</sup>
- Delayed hyponatremia in 1 – 2.4%<sup>1,2</sup>
- Recurrence 16% at 10 yrs<sup>3</sup>
- Recurrence requiring surgery 6% at 10 yrs<sup>3</sup>
- 33% recur if residual tumor present<sup>4</sup>
- 3% recur if complete resection

1. Arlita K, et al. Endocr J 1996;43:131-8.
2. Laws ER Jr, Thapar K. Endocrinol Metab Clin North Am 1999;28:119-31.
3. Laws ER, Jane JA Clinical Neurosurgery. 2001;48:306-319.
4. Critch, et al. Neurosurgery 1997;40:225-36.

# Cushing's Disease

## Cushing's Syndrome



### Cushing's Syndrome: Non-specific Signs and Symptoms

- Hypertension
- Centripetal Obesity
- Diabetes Mellitus
- Osteoporosis
- Amenorrhea
- Supraclavicular Fat Pad
- Cervical Fat Pad

### Cushing's Disease: Specific Signs and Symptoms

- Moon Facies
- Purple Striae
- Proximal Muscle Weakness
- Mass Effect

### Cushing's Disease: Screening Tests

#### 24 h Urine free cortisol

< 50 $\mu\text{g/day}$	ruled out
51 - 299 $\mu\text{g}$	suspected
$\geq 300$ $\mu\text{g}$	probable

#### Overnight 1 mg Dex suppression

< 2 $\mu\text{g/dL}$	ruled out
2 - 5 $\mu\text{g/dL}$	suspected
> 5 $\mu\text{g/dL}$	probable

### Cushing's Disease: Diagnostic Tests

#### Low-dose Dexamethasone Suppression Test

Dexamethasone 0.5mg po q6hr x 8 doses

#### Collect urine for 3 days

one day prior and each day of test

#### The following rule out Cushing's:

Urine Cortisol < 10 $\mu\text{g}$

Urine 17-OHCS < 2.5 mg

Serum cortisol < 2  $\mu\text{g/dL}$  (6hrs after last dex dose)

## Cushing's Syndrome: Localizing Tests

### High-dose Dex Suppression

Overnight 8 mg

Normal AM cortisol undetectable  
Cushing's Disease AM cortisol < 50% baseline

### Standard 2-day (Dex 2mg po q6h x 8 doses)

Normal AM cortisol undetectable  
24 h cortisol < 5 µg  
24 h 17-OHCS < 2.5 mg  
Cushing's Disease 24 h cortisol < 10%  
24 h 17-OHCS < 36%

## Inferior Petrosal Sinus Sampling



[www.urmc.rochester.edu/smd/Rad/orderneuro.htm](http://www.urmc.rochester.edu/smd/Rad/orderneuro.htm)

## Cushing's Disease: Results of Surgery

- Cure achieved in 80% of microadenomas<sup>1</sup>  
Can be hypocortisolemic for up to 18 months  
Length of time to axis recovery correlates with cure
- Remission overall in 70 – 80% of corticotroph tumors<sup>2</sup>  
Using mean serum cortisol measurements of 5.4 – 10.8 µg/dL and normal UFC, recurrence in ≥ 25% at 10 yrs  
Serum cortisol < 1.8 µg/dL within 2 weeks post-op predicts recurrence 40 – 65%
- Bilateral adrenalectomy  
Nelson's syndrome

1. Larsen: Williams Textbook of Endocrinology, 10th ed., 2003 Saunders  
2. Arnaldi G, et al. J Clin Endocrinol Metab 2003; 88:5593-5602

## Cushing's Disease: Steroidogenic Inhibitors

- Metyrapone  
Inhibits 11β-hydroxylation  
Ataxia, dizziness, rash, nausea, edema, hirsutism
- Aminoglutethimide  
Inhibits conversion of cholesterol to pregnenolone  
Sedation, nausea, anorexia, rash
- Ketoconazole  
Inhibits many steps in cortisol production  
Increased transaminases, GI upset, edema, gynecomastia
- Mitotane  
Inhibits many steps of cortisol production – destroys adrenal tissue  
GI distress, dizziness, impaired mentation, increased transaminases, rash, hyperlipidemia

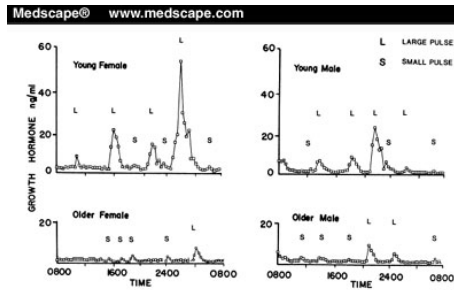
## Cushing's Disease: Neuromodulatory Agents

- Cyproheptadine
  - Decreases ACTH secretion
  - Somnolence, hyperphagia, weight gain
- Cabergoline
  - Decreases ACTH secretion
  - Nausea, vomiting, orthostasis, GI upset
- Valproic Acid
  - Decreases ACTH secretion
  - Hepatotoxicity, teratogen

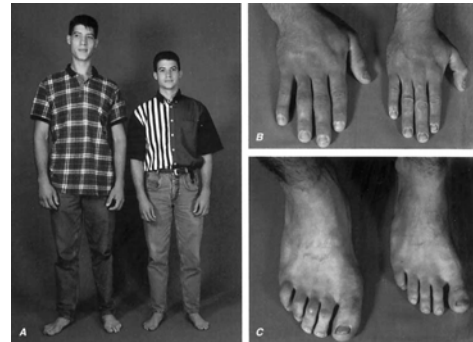
## Acromegaly



## Normal Growth Hormone Secretion



## Acromegaly

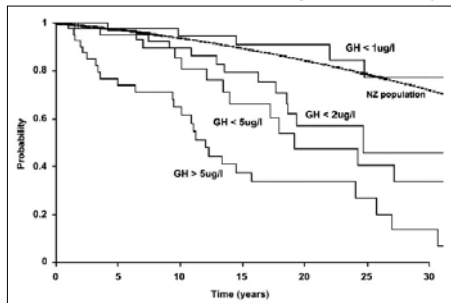


## Acromegaly Diagnosis

- Nadir GH after 75g OGTT
  - GH < 1 µg/L (< 2 mU/L) = WNL
  - 1 µg/L < GH < 1.5 µg/L = Probably acromegaly
  - GH > 1.5 µg/L = acromegaly
- IGF-I
  - IGF-I < 250 ng/mL = Probably WNL
  - 250 ng/mL < IGF-I < 500 ng/mL = probably acromegaly
  - IGF-I > 500 ng/mL = acromegaly

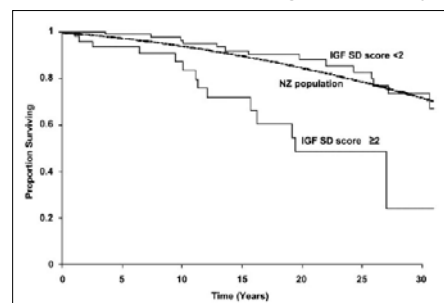
Acromegaly Series	Number of Cases	Total Cure Rate (%)	Microadenomas (%)	Macroadenomas (%)	Definition of "Cure"
Ross and Wilson, 1988	153	56	NA	NA	GH < 5 µg/L (< 10 mU/l)
Losa et al., 1989	29	55	NA	NA	GH < 1 µg/L (< 2 mU/l) and normal IGF-I levels
Fahlbusch et al 1992	222	57	72	49	GH < 2 µg/L (< 4 mU/l) after OGTT
		71	81	65	GH < 5 µg/L (< 10 mU/l)
Tindall et al 1993	91	82	NA	NA	GH < 5 µg/L (< 10 mU/l) and/or normal IGF-I levels
Davis et al., 1993	174	52	NA	NA	GH < 2 µg/L (< 4 mU/l; basal or OGTT)
Sheaves et al., 1996	100	42	61	23	GH < 2.5 µg/L (< 5 mU/l)
Abosch et al., 1996	254	76	75	71	GH < 5 µg/L (< 10 mU/l)
Freda et al., 1998	115	61	88	53	GH < 2 µg/L (< 4 mU/l) OGTT or normal IGF-I levels
Swearingen, 1998	162	57	91	48	Normal IGF-I levels
Lisselt, 1998	73	18	39	12	GH < 5 µg/L OGTT
Ahmed et al., 1999	97	—	90	56	Basal GH < 2.5 µg/L, OGTT GH < 1 µg/L, normal IGF-I levels
Laws et al., 2000	117	67	87	51	Basal GH < 2.5 µg/L, OGTT GH < 1 µg/L, normal IGF-I levels
Fahlbusch, 2001	490	56	78	50	Basal GH < 5 µg/L, OGTT GH < 2 µg/L, normal IGF-I levels

## Acromegaly: Factors Influencing Mortality



Holdaway IM, et al. J Clin Endocrinol Metab 2004; 89:667-674

## Acromegaly: Factors Influencing Mortality



Holdaway IM, et al. J Clin Endocrinol Metab 2004; 89:667-674

## Acromegaly: Somatostatin Analogs

20 treatment-naïve acromegalics (10 macro/10 micro) treated with Octreotide LAR® up to 30 mg or Lanrotide SR® up to 30 mg

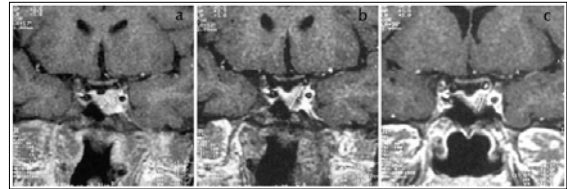
	Macroadenoma	Microadenoma	P-value
Basal serum GH levels (µg/l)	73.6 ± 25.0	49.2 ± 27.0	<0.05
Basal IGF-1 levels (ng/ml)	584.0 ± 148.0	548.4 ± 225.0	NS
Patients attaining GH value < 5.0 mU/l at T12 (%)	10/10	6/10	<0.05
Patients attaining GH value < 5.0 mU/l at T24 (%)	10/10	9/10	<0.05
Patients attaining normal IGF-1 values at T12 (%)	20/0	7/10	NS
Patients attaining normal IGF-1 values at T24 (%)	4/10	7/10	NS
Shrinkage (% volume reduction) at T12	40.5 ± 17.0	16.1 ± 8.0	<0.05
Shrinkage (% volume reduction) at T24	43.7 ± 16.8	20.2 ± 10	<0.05

T12, 12th month of therapy; T24, 24th month of therapy. The data are expressed as mean ± SD. NS, not significant.

Amato G, et al Clin Endocrinol 2002; 56:65-71

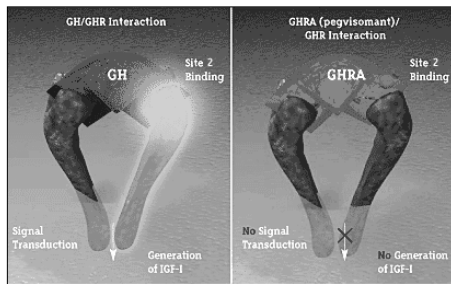
## Acromegaly: Somatostatin Analogs

Baseline 12 months 24 months



Amato G, et al Clin Endocrinol 2002; 56:65-71

## Acromegaly: Pegvisomant



[http://www.somavert.com/professionals/images/blocks\\_effects\\_B.gif](http://www.somavert.com/professionals/images/blocks_effects_B.gif)

## Acromegaly: Pegvisomant

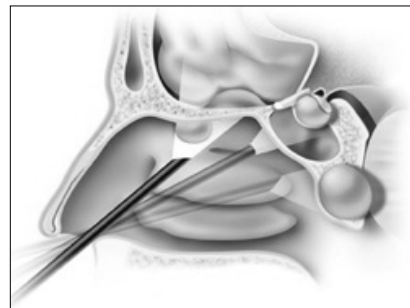
12 months of pegvisomant 10 – 40 mg/day in patients resistant to high-dose somatostatin analog

	Before	After	P
Weight (kg)	83.5 ± 15.0	85.7 ± 13.6	0.055
Serum GH levels (µg/l)	22.9 ± 24.0	34.5 ± 40.4	0.29
Serum IGF-1 levels (µg/l)	775.1 ± 111.4	292.8 ± 105.7	<0.001
Tumor volume (mm <sup>3</sup> )	1198 ± 1234	1196 ± 1351	0.37
Ring size (mm)	12.7 ± 2.2	12.2 ± 2.3	0.78
Systolic blood pressure (mmHg)	133.9 ± 16.2	129.6 ± 10.1	0.13
Diastolic blood pressure (mmHg)	87.1 ± 13.6	86.2 ± 7.1	0.70
Heart rate (bpm)	72.8 ± 7.6	79.8 ± 7.9	0.14
Total cholesterol levels (mmol/l)	5.3 ± 1.0	5.5 ± 0.8	0.43
HDL cholesterol levels (mmol/l)	1.2 ± 0.3	1.5 ± 0.2	0.0017
Total HDL cholesterol ratio	4.5 ± 1.0	3.7 ± 0.6	0.0019
Triglyceride levels (mmol/l)	1.5 ± 0.9	1.5 ± 0.7	0.86
Glucose levels (mmol/l)	5.6 ± 1.9	4.8 ± 1.4	0.0132
HbA1c levels (%)	5.9 ± 0.7	5.3 ± 0.5	0.24
Insulin levels (mU/l)	12.4 ± 6.7	8.1 ± 3.0	0.0023
HOMA index	3.4 ± 2.1	1.9 ± 1.0	0.0017
Fibrinogen levels (mg/dl)	342.1 ± 75.2	361.6 ± 63.6	0.58
AST levels (U/l)	18.4 ± 8.6	22.9 ± 15.1	0.64
ALT levels (U/l)	15.6 ± 14.0	45.1 ± 51.2	0.017
Albumin levels (g/dl)	3.8 ± 0.4	4.4 ± 0.3	0.0002

Colao A, et al Eur J Endocrinol 2006; 154:467-477

## Surgical Advances

## Surgical Advances: Endoscopy



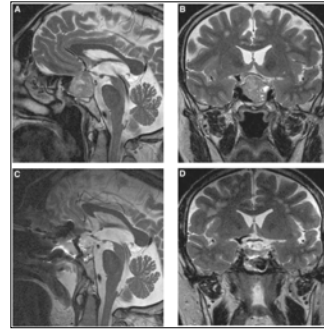
<http://www.cornellneurosurgery.org/endoscopicskullbase/>

## Surgical Advances: Intraoperative MRI



<http://www.imaginginformatics.ca/correct.jpg>

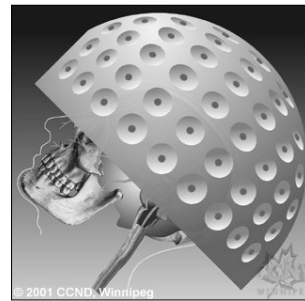
## Surgical Advances: Intraoperative MRI



Buchfelder M. Endocrine 2005; 28:67-75

## Advances in Radiotherapy

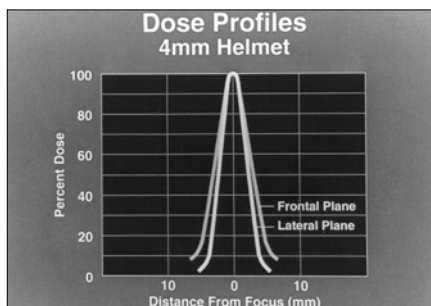
## Radiotherapy: Gamma Knife



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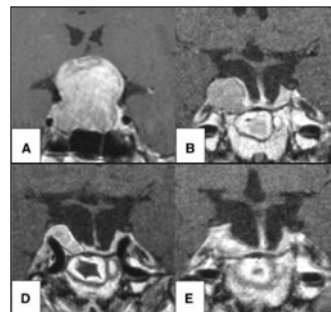
[http://www.umantoba.ca/cranial\\_nerves/trigeminal\\_neuralgia/manuscript/images/gamma.jpg](http://www.umantoba.ca/cranial_nerves/trigeminal_neuralgia/manuscript/images/gamma.jpg)

## Radiotherapy: Gamma Knife



Jackson IMD and Noren G Balliere's Clin Endocrinol Metab 1999; 13:461-469

## Radiotherapy: Gamma Knife



Akabane A, et al Endocrine 2005; 28:87-91

## Radiotherapy: Stereotactic Fractionated Radiotherapy

- Focuses multiple low dose beams like gamma knife
- But has multiple sessions as opposed to one session
- Requires anchors to be surgically placed
- Might be better for lesions close to the optic chiasm  
i.e. gives the chiasm, which is radiosensitive,  
time to "rest" between radiation doses