THE NORTHERN HOSPITAL

HYDROCORTISONE

"David with the Head of Goliath", oil on canvas. c.1605- 6,
Michelangelo Merisi da Caravaggio. (Borghese Gallery, Rome).

Italy. 1610.

Michelangelo Merisi da Caravaggio is on the run. Again.

No stranger to trouble, this artist's tangled with the law most of his life.

But this time, it's different. This time, he's wanted for murder.

There's a price on his head - alive or dead.

So he does what he's always done - does what he does best. He tries to paint his way out of trouble.

This is what he paints - David with Head of Goliath. It's a self-portrait.

But why doesn't Caravaggio cast himself as the hero, David?

Why does he paint himself as the villain of the piece, the monster, Goliath?

Maybe he hopes that by making this guilty plea in paint he can be spared.

Perhaps by offering his head in a painting he can save himself in real life.

We like to think, don't we, that the genius is the hero, that the good guy wins,

but this is Caravaggio. And the genius is the villain….

…Barely a month after he's been admitted to the Order of St. John, Caravaggio's imprisoned for assaulting a brother knight. But, incredibly, he manages to escape from his underground cell, over the castle walls, and into a boat which takes him to Sicily.

He returns to the safety of Naples, and it's here his enemies finally catch up with him.

He's jumped, leaving an inn, his face and head slashed and gashed so badly, he's left for dead.

But he doesn't die, and in this, his darkest moment, recovering from his beating, news reaches him from Rome.

The pope's nephew, Scipione Borghese, is arranging a pardon.

So Caravaggio sets about repaying him, the only way he can, the only way he's ever got anywhere.

It's a self-portrait, unlike any painted before.

Usually when artists looked in the mirror they liked what they saw, and what they saw were men, young or old, whose features were ennobled by their calling, to bring virtue, beauty and grace into the world.

Now, look at Caravaggio. A decapitated head. He's Goliath. A bloody grotesque. A monster.

In the beheading of John the Baptist, evil was done by other people. Here it's Caravaggio who's the embodiment of wickedness.

In this victory of virtue over evil, David is supposed to be the center of attention, but have you ever seen a less jubilant victor?

On his sword is inscribed, "humilitas occidit superbiam", humility conquers pride.

A battle that's been fought out inside Caravaggio's head, between the two sides of the painter portrayed here.

There's the devout, courageous David Caravaggio, and then there's the criminal sinner, Goliath Caravaggio.

"I know who I've been", says the pathetic head, unable to look us in the eyes,

"I know what I've done". It's a desolate vision, offered to us in utter blackness, no virtue, no grace. Just the dark truth from the inside of Caravaggio's head, flooded with tragic self-knowledge.

For me, the power of his art is the power of truth, not least about ourselves.

For if we're ever to have a chance of redemption, it must begin with an act of recognition that in all of us the Goliath competes with the David.

In July 1610, Caravaggio rolled up his paintings and set sail from Naples, finally heading home. Sailing north, his boat stopped at the tiny harbor of Parlo, on the coast just west of Rome. Here, the local captain of the guard either hadn't heard about his pardon or mistook him for some other fugitive.

Either way, he's thrown in jail.

By the time he's managed to pay his way out, his boat has sailed off, along with his paintings, his offering to Borghese.

Desperate to catch up with his ship with its precious cargo, Caravaggio sets off north towards Porto Ercole, 100 kilometers through the malarial infested swamp country, the Miramar. Here, the final disaster awaited.

In pathetic attempt to hail a ship, Caravaggio starts running along the beach under the broiling July sun before collapsing in the sand.

By now he's suffering from a raging fever, and is taken to a local monastic hospital.

There, according to a contemporary report, "without the aid of God or man, he died, as miserably as he'd lived".

It's sometime later that the pope's nephew, Scipione Borghese, finally receives the paintings with which Caravaggio had hoped to win his pardon. The cardinal finds himself face to face with the picture of the painter as the slain Goliath.

The cardinal isn't used to this.

Artists had been given their gift by God to bring beauty into the world, to put mortal creatures in touch with their higher selves. That's the way it was supposed to be.

But Caravaggio never did anything the way it was supposed to be.

"Here I am", says this dead face which seems still alive, "They said whoever delivers my head will get a reward. Well, I'm turning myself in. Will that do? Can I have my reward? Can I have my pardon?"

"Sorry", says the cardinal. "So sorry. You're too late".

Simon Schama, "The Power of Art", BBC Television, 2010.

An intriguing theory is held by some Art historians that Caravaggio's "David with the Head of Goliath", is actually a double - portrait. Simon Schama explains: "His youthful upper body washed with light, David is the blessed Caravaggio that ***was****, the Caravaggio of his prodigious beginnings, the maker of Christian beauty (the slingshot of his conquest has been assimilated into the loose shirt tied about his waist, a piece of white fabric as exquisitely tactile as anything the painter had ever rendered). But that same light flows downwards on to the face of the ogre, the Caravaggio that* ***is****, the bisexual goat, the murderer, the immense encyclopaedia of wickedness".*

In all of Simon Schama's brilliant commentary on Michelangelo Merisi da Caravaggio, two observations perhaps best sum up his work and his life. "For if we're ever to have a chance of redemption, it must begin with an act of recognition that in all of us the Goliath competes with the David". Though he had been blessed with a god-like talent few in history have ever possessed, which brought him great fame and renown, this in the end did not give him happiness or even peace of mind. He fought an unending battle against the Goliath within. The dark side of his psyche meant that he had few real friends, and certainly no family that would be there with him when all others had abandoned him. "Without the aid of God or man, he died, as miserably as he'd lived".

We must approach the corticosteroids with some little trepidation. Though they have a miraculous ability to do great works, like the tormented Caravaggio they also possess a dark Goliath within; that with the passage of time will be ever more likely to show itself!

HYDROCORTISONE

Introduction

Hydrocortisone (or **cortisol** - trade name in Australia, "**Solu-Cortef**") is a naturally occurring **corticosteroid** hormone which has both **glucocorticoid** and **mineralocorticoid effects.**

It is used in a wide variety of conditions, *principally* for its:

- **Anti-inflammatory effects**
- **Anti-allergy effects**
- **Immunosuppressant effects.**
- **Adrenal support in states of absolute or relative adrenal deficiency.**

As a class the glucocorticoids, when used in **supraphysiological** doses, have a large number of adverse effects.

Most of these adverse effects however relate to **long term** treatment and **do not preclude short term use.**

History

Cortisone was first identified by the American chemists **Edward Calvin Kendall** (1886 - 1972) and **Harold L. Mason** while researching at the Mayo Clinic.

Kendall was awarded the **1950 Nobel Prize for Physiology or Medicine** along with **Philip S. Hench** and **Tadeus Reichstein** for the discovery of adrenal cortex hormones as well as their structures and functions.

Harold. Mason's contributions to the crystallization and characterization of cortisol have generally been forgotten outside of the Mayo Clinic.

Chemistry

Cholesterol → cortisol (or hydrocortisone) → cortisone (less active metabolite).

Physiology

The principle physiological roles of the corticosteroids are widespread and complex, but essentially fall into three groups:

1. Enhancing the effects of circulating catecholamines
2. Metabolic effects

3. Global suppression of anti-inflammatory and immune responses

At the highest level, the corticosteroids are said to enable and enhance the complex cardiovascular and metabolic "fight or flight" survival responses of the organism to the presence of "stressors" (e.g trauma, infection, surgery).

Classification

Naturally occurring adrenocortical steroids:

The **naturally occurring** adrenocortical steroids are:

- **Hydrocortisone (or cortisol)**
- **Cortisone**

These have both anti-inflammatory (glucocorticoid) and salt retaining properties, ie mineralocorticoid properties).

They are principally used as replacement therapy in adrenocortical deficiency states.

Synthetic corticosteroids:

The **synthetic** corticosteroid compounds include:

- **Prednisolone**
- **Prednisone**
- **Dexamethasone**
- **Methylprednisolone**
- **Fludrocortisone**

These are mainly used for their anti-inflammatory properties.

Classification according to predominant activity:

1. Synthetic agents with *marked glucocorticoid* activity and an *absence* of significant salt-retaining activity:
    - **Dexamethasone**
    - **Prednisolone**
    - **Methylprednisolone**

- **Betamethasone**

These drugs are primarily used for their potent anti-inflammatory effects.

2. Synthetic agents with predominant mineralocorticoid activity:

- **Fludrocortisone**

It is used as a mineralocorticoid replacement for patients with primary adrenal insufficiency and as a treatment for orthostatic hypotension.

3. Agents with a combination of both *glucocorticoid* activity and mineralocorticoid activity.

- **Hydrocortisone**

Preparations

Available preparations include:

Ampoules (as hydrocortisone sodium succinate) :

- 100 mg/2 mL (Powder for reconstitution with diluent).
- 250 mg/2 mL (Powder for reconstitution with diluent).
- 500 mg/4 mL (Powder for reconstitution with diluent).

Hydrocortisone sodium succinate is a highly water soluble sodium succinate ester of hydrocortisone that permits the immediate intravenous administration of high doses of hydrocortisone in a small volume of diluent and is particularly useful where high blood levels of hydrocortisone are required rapidly.

Hydrocortisone *sodium succinate* has the same metabolic and anti-inflammatory actions as natural endogenous hydrocortisone. When given parenterally and in equimolar quantities, the two compounds are equivalent in biological activity.

Tablets:

- Hydrocortisone 5mg tablets
- Hydrocortisone 20mg tablets

Topical (Creams or ointments as hydrocortisone acetate):

- 0.5 %

- 1.0 %

See also Topical Steroids (in Drugs folder).

Mechanism of Action

The corticosteroids **regulate gene expression**.

When a corticosteroid enters a cell, it combines with corticosteroid receptors in the cytoplasm.

This drug-receptor complex enters the nucleus where it controls synthesis of protein, including enzymes that regulate cell activity such as inflammation.

Pharmacodynamics

Effects of the corticosteroids in general include:

1. Glucocorticoid effects including:
    - **Enhancing the vascular sensitivity to circulating catecholamines.**
    - Metabolic effects:
        - ♥ Gluconeogenesis:
            - ♥♥ This is the generation of glucose from *non-carbohydrate* carbon substrates such as pyruvate, lactate, glycerol, and glucogenic amino acids.
        - ♥ Proteolysis
        - ♥ Lipolysis
        - ♥ All corticosteroids can increase calcium excretion
    - Suppression of inflammation and immune responses.
2. Mineralocorticoid effects including:
    - Hypertension
    - Sodium and water retention
    - Potassium loss.

The corticosteroids as a group may have predominantly glucocorticoid effects (e.g. dexamethasone), mineralocorticoid effects (fludrocortisone), or a combination of both (e.g. **hydrocortisone**).

Note that *systemic effects* may result from all of oral, intramuscular, intravenous, inhaled, intra-articular and topical administration.

Pharmacokinetics

Absorption:

- Hydrocortisone is given IV.

  Following the **intravenous injection** of hydrocortisone sodium succinate, demonstrable effects are evident within **1 hour** and persist for a variable period.

  This preparation is also rapidly absorbed when administered intramuscularly, although the intravenous route is preferred.

  Hydrocortisone can also be given orally.

  Hydrocortisone can be given topically for some inflammatory dermatologic conditions.

Distribution:

- Hydrocortisone is widely distributed to all body tissues.

Metabolism and excretion:

- Excretion of the intravenously administered dose is nearly complete within 12 hours.

  Intramuscular injections are excreted in a pattern similar to that observed after intravenous injections.

- The estimated **biological** half life of hydrocortisone is 8 - 12 hours.

Indications

Hydrocortisone indications include:

1. Acute broncho-inflammatory conditions:

   Corticosteroids are widely used in the treatment of airways disease to reduce bronchial inflammation and hyper-responsiveness.

   - Moderate - severe asthma

- Moderate - severe COPD

The indications for other conditions causing bronchospasm are less well defined, however hydrocortisone is still widely prescribed for these, as well, including:

- Aspiration induced wheeze.

2. Allergic conditions:

   - Anaphylaxis
   - Severe anaphylactoid reactions
   - Other allergic conditions in general.

3. Immunosuppression:

   Corticosteroid may be used by appropriate specialists or under their supervision for various rheumatic or autoimmune type conditions, including:

   - Inflammatory bowel disease (in conjunction with other agents):
     - ♥ Crohn's disease and ulcerative colitis (to induce remission).
   - Some dermatological diseases:
     - ♥ Hydrocortisone may be used for some severe inflammatory dermatological conditions, such as pemphigus Stevens-Johnson syndrome exfoliative dermatitis; bullous dermatitis herpetiformis; severe seborrhoeic dermatitis; severe psoriasis; mycosis fungoides.
   - Some rheumatic disorders:
     - ♥ Hydrocortisone may be used as adjunctive therapy for short-term treatment (to tide the patient over an acute episode or exacerbation) of a wide range of conditions including: post-traumatic osteoarthritis; synovitis of osteoarthritis; rheumatoid arthritis, including juvenile rheumatoid arthritis (selected cases may require low dose maintenance therapy); acute and subacute bursitis; epicondylitis; acute nonspecific tenosynovitis; acute gouty arthritis; psoriatic arthritis; ankylosing spondylitis.

       It may also be used during an exacerbation or as maintenance therapy in selected cases of SLE and systemic dermatomyositis/ polymyositis.

- Acute exacerbations of multiple sclerosis, (though methylprednisolone is usually preferred).

- Some haematological disorders:

  ♥ Acquired (autoimmune) haemolytic anaemia; idiopathic thrombocytopenic purpura in adults (secondary thrombocytopenia in adults; congenital (erythroid) hypoplastic anaemia.

- Some neoplastic diseases

- Some ophthalmic diseases:

  ♥ Severe acute and chronic allergic and inflammatory processes involving the eye, such as: Herpes zoster ophthalmicus; iritis, iridocyclitis; chorioretinitis; diffuse posterior uveitis and choroiditis; optic neuritis; sympathetic ophthalmia; anterior segment inflammation; allergic conjunctivitis; allergic corneal marginal ulcers; keratitis.

4. Replacement therapy in situations of absolute or relative adrenal insufficiency:

   - Acute adrenal insufficiency:

     ♥ Including **relative** corticosteroid insufficiency in patients with severe septic shock.

   - Acute pituitary failure.

   - Adrenal insufficiency due to chronic steroid suppression:

     ♥ In patients on longer term corticosteroid therapy who are subjected to unusual stress, (e.g. sepsis, trauma, surgery) increased dosage of rapidly acting corticosteroids before, during, and after the stressful situation is indicated.

5. Adjunctive therapy in some situations of hypercalcaemia:

   Intravenous glucocorticoid is sometimes required in individuals with refractory hypercalcaemia due to conditions where excess vitamin D production is known to be the cause of the hypercalcaemia, such as:

   - Certain Malignancies.

   - Vitamin D intoxication.

   - Sarcoidosis, (or other “granulomatous” diseases).

Contra-indications/precautions

These include:

1. Infections (caution):

   Immunosuppression can increase the risk and severity of infection and so caution is advised when prescribing hydrocortisone in a patient with active or latent infection.

   Some conditions require *both* corticosteroid and control of infection, (e.g. infective exacerbation of COPD or asthma) and this is usually safe so long as the infection can be effectively treated at the same time.

   In general terms, the decision to start or continue corticosteroids in a patient with infection depends on a number of factors including:

   - The type of infection:
     - ♥ Including whether active or latent
     - ♥ **Systemic fungal** infections generally contraindicate the use of corticosteroids.
   - Its severity
   - Whether the infection can be treated or controlled at the same time.
   - The specific indication for hydrocortisone.

2. Live vaccines:

   - Administration of live or live attenuated vaccines is contraindicated in patients receiving **immunosuppressive doses** of corticosteroids.

     Killed or **inactivated** vaccines may be administered to patients receiving immunosuppressive doses of corticosteroids, however the response to such vaccines may be diminished.

3. Known hypersensitivity to the excipients of Solu-Cortef

4. Intra-articular injection (corticosteroids in general):

   - Corticosteroids are contraindicated in patients with infective arthritis, skin or soft tissue infections near joint (risk of introducing bacteria into joint) or a prosthetic joint.

*The following **precautions** do not apply when used at **physiological doses for adrenal insufficiency**:* [2]

5. Latent TB:

    - May be reactivated; consider treatment with isoniazid.

6. Peptic ulcer disease:

    - Corticosteroids may increase the risk of peptic ulcers.

7. Diabetes:

    - Corticosteroids (including intra-articular injections) may cause hyperglycaemia and worsen diabetes control.

8. Hypertension/ heart failure:

    - May be worsened due to sodium and water retention (mineralocorticoid effect).

9. Psychiatric disorders:

    - May be exacerbated.

10. Glaucoma:

    - Intraocular pressure may increase.

11. Osteoporosis:

    - Long-term corticosteroid use increases the risk of osteoporotic fractures and accelerates bone loss.

12. Myasthenia gravis:

    - Increased muscle weakness may occur during the first few weeks of treatment with corticosteroids; (seek specialist advice).

Pregnancy

Hydrocortisone is a category A drug with respect to pregnancy.

Category A drugs are those drugs which have been taken by a large number of pregnant women and women of childbearing age without any proven increase in the frequency of malformations or other direct or indirect harmful effects on the fetus having been observed.

Note that **hydrocortisone, prednisolone, prednisone** and **methylprednisolone** are the preferred agents for maternal disorders as placental transfer is limited, while **betamethasone** and **dexamethasone** are the preferred agents for fetal disorders as placental transfer is greater. [2]

Breast feeding

Hydrocortisone is safe in pregnancy.

Adverse Effects

Adverse effects are an inevitable result of **systemic** corticosteroid treatment if the **dose and/ or duration** of treatment are sufficient, because most are dose-related biological effects of the hormone.

Short courses of high dose systemic treatment cause fewer adverse effects than prolonged courses of lower doses.

The *longer - term* adverse effects of corticosteroids *in general* include:

Adverse glucocorticoid effects:

1. Adrenal suppression

   Manifests with longer term exogenous administration when:

   - Therapy is **abruptly ceased**

   Or

   - When a **stressor occurs**; due to secondary adrenocortical and pituitary unresponsiveness, particularly in trauma, surgery, infection or illness

   Adrenal hypofucntion can lead to Shock/ increased risk of shock states.

   The hypothalamic-pituitary-adrenal axis is suppressed by glucocorticoid therapy.

   The dose, duration of treatment and individual patient characteristics affect the onset and extent of this effect.

   Treatment with **prednisolone** at doses **greater than 10 mg** (or equivalent dose of glucocorticoid) **daily for more than three weeks** can be considered sufficient to cause clinically significant adrenal suppression that requires glucocorticoid replacement at a time of intercurrent illness, trauma or surgical stress. [1]

   Therefore, in this situation, tapering of the glucocorticoid dose is required to avoid both adrenal insufficiency and the rebound in symptoms that may occur with sudden cessation.

After long-term use (more than 2 weeks), dose reduction must be slow to enable the hypothalamic-adrenal feedback system to re-equilibrate.

2. Immunosuppression:

- Increased risk of infection.
- Infections are more common in people treated with supraphysiological doses of corticosteroids, due to immunosuppressive effects.
- **Corticosteroids may also mask the early symptoms and signs (by suppressing the inflammatory repose) of infection, resulting in later diagnosis, delay in treatment, and more severe clinical consequences.**
- Reactivation of *Mycobacterium tuberculosis* infection occurs with such frequency that before commencing immunosuppressant treatment with corticosteroids, screening for active or latent tuberculosis (TB) should be considered.
- Prophylaxis for *Pneumocystis jiroveci (carinii)* infection should be considered in patients who are at risk and taking high dose oral corticosteroids long term.

3. Metabolic effects:

- Hyperglycaemia:
  - ♥ Hyperglycaemia may accompany treatment with corticosteroids, particularly when higher doses are used, and blood glucose concentrations may require monitoring.
- Hypertriglyceridaemia
- Weight gain/ redistribution of fat centripetally, leading to the development of a "Cushingoid" state.
- All corticosteroids increase calcium excretion

4. Dermatological effects:

- Skin atrophy leading to thin fragile skin.
- Purpura/ ecchymoses
- **Poor wound healing**
- Striae

- Hirsutism

5. Gastrointestinal effects:

   - Dyspepsia
   - Peptic ulceration
   - Gastrointestinal bleeding

6. Myopathy:

   - Steroid myopathy with muscle weakness/ loss of muscle mass.
   - Tendon rupture can also occur, particularly of the Achilles tendon

7. Bone effects:

   - Osteoporosis:
     - ♥ **Bone density loss** leading to osteoporosis is a risk for patients on continuous (> one month) corticosteroid therapy in doses greater than the equivalent of prednisolone **5 to 7.5 mg per day** or who are receiving frequent pulses of corticosteroid.
     - ♥ It can occur in men as well as women.
     - ♥ The risk of osteoporosis becomes greater at higher glucocorticoid doses.
     - ♥ Loss of bone mineral density occurs rapidly after corticosteroids are commenced and may exacerbate the osteoporosis associated with some rheumatological diseases, such as ankylosing spondylitis, and inflammatory bowel disease.
   - Avascular (ischaemic) necrosis:
     - ♥ Most typically of the of the proximal femoral and humeral head
     - ♥ It is infrequent
     - ♥ It is idiosyncratic (ie unpredictable).
     - ♥ It occurs more commonly following exposure to doses in excess of **20 mg** per day prednisolone (or equivalent dose of other corticosteroid).

- ♥ The time between corticosteroid exposure and the development of avascular necrosis is variable, and can be up to *many years*, which makes diagnosis difficult.

- ♥ Avascular necrosis should be considered in the differential diagnosis of hip and groin pain especially in patients who have been on high-dose and/or long-term corticosteroids at any time.

- ♥ Both the pathogenesis and treatment of this condition remain controversial.

8. Ocular effects:

   - Increased intraocular pressure
   - Cataracts

9. Growth retardation in children:

   - Chronic use of corticosteroids (at pharmacological doses) may retard growth in children.
   - Follow growth and development carefully
   - Catch-up growth may occur after corticosteroid withdrawal.

10. Menstrual irregularities:

    - Principally amenorrhoea

11. Psychiatric disturbances:

    - Euphoria
    - Depression
    - Paranoid psychosis

    Note that preexisting emotional instability or psychotic tendencies may also be *aggravated* by corticosteroids.

Adverse mineralocorticoid effects:

1. Sodium retaining effects:

   - Oedema
   - Hypertension

2. Hypokalaemic alkalosis.

Note that most of the adverse effects relate to long term treatment and do not preclude *short* term use.

Corticosteroids applied topically can also cause adverse effects

Dosing

Exact dosing and the duration of dosing depends on the condition being treated as well as the severity of the condition and illness.

See latest Therapeutic Guidelines for full prescribing details.

Reconstituted solution is generally given as undiluted solution by slow IV injection.

In *general* terms for Adults:

- **Hydrocortisone 100 mg - 250 mg IV 6 hourly (or 4 hourly if more severe symptoms)** [2]

  Children: Acute severe asthma, **4 mg/kg (maximum 100 mg) IV every 4 - 6 hours.**

For the *initial control* of some autoimmune or inflammatory diseases, **100 - 500 mg IV 6-8 hourly** according to severity of condition, may be prescribed under specialist supervision. [2]

Use of steroid sparing drugs:

When corticosteroids are required for longer term use, drugs from other classes may be used to allow a reduction of the corticosteroid dose.

For example, in rheumatology, use of disease modifying anti-rheumatic drugs (DMARDs) and NSAIDs often allows a lower corticosteroid dose to be used.

Appendix 1

Approximate relative potencies and half-lives of the glucocorticoids:

Glucocorticoid	Relative glucocorticoid potency	Equivalent dose for glucocorticoid effect	Estimated biological half-life
Hydrocortisone	1	20 mg	8 to 12 hours
Cortisone acetate	0.8	25 mg	8 to 12 hours
Dexamethasone	25 to 50	400 to 800 micrograms	36 to 54 hours
Prednis(ol)one	4	5 mg	18 to 36 hours
Methylprednisolone	5	4 mg	12 to 36 hours

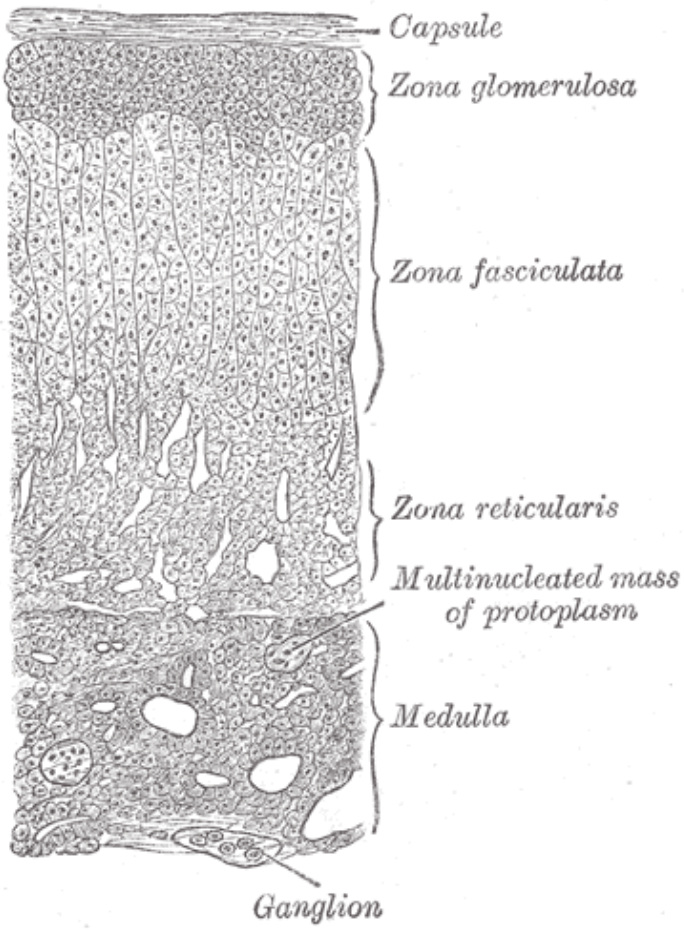
Appendix 2

Relative potencies of the topical preparations of the corticosteroids:

Mild	
Desonide	0.05%
Hydrocortisone	0.5%, 1%
Hydrocortisone acetate	0.5%, 1%
Moderate	
Betamethasone valerate	0.02%, 0.05%
Clobetasone butyrate	0.05%
Methylprednisolone aceponate	0.1%
Triamcinolone acetonide	0.02%
Potent	
Betamethasone dipropionate	0.05%
Betamethasone valerate	0.1%
Mometasone furoate	0.1%
Triamcinolone acetonide	0.1%
Very potent	
Betamethasone dipropionate	0.05% in optimised vehicle
Clobetasol propionate	0.05%

Appendix 3

Physiology of the Adrenal Gland:



Cross sectional anatomy of the adrenal gland, (Gray's Anatomy 1918).

The Adrenal Cortex:

This consists of **3 zones**:

- Zona glomerulosa:
  - ♥ This layer is the main site for production of the **mineralocorticoid** hormone, **aldosterone.**
- Zona fasciculata:
  - ♥ This layer is the main site for production of the **glucocorticoids** (mainly **cortisol**).

- Zona reticularis:

    - ♥ This layer is the main site for production of **androgens**; mainly dehydroepiandrosterone (DHEA), DHEA sulfate (DHEA-S), and androstenedione (the precursor to testosterone) in humans.

The Adrenal Medulla:

- The chromaffin cells of the medulla are the body's main source of the circulating catecholamines; **adrenaline** (80 %) and **noradrenaline** (20 %).

"David with the Head of Goliath", (Detail) oil on canvas. c.1605- 6, Michelangelo Merisi da Caravaggio. (Borghese Gallery, Rome).

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1 eTG - March 2015

2. Hydrocortisone in Australian Medicines Handbook, Accessed February 2015

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Dr J. Hayes
Reviewed May 2016.