

SOLU-MEDROL
Methylprednisolone

1. NAME OF THE MEDICINAL PRODUCT

SOLU-MEDROL

2. QUALITATIVE AND QUANTITATIVE COMPOSITION

Active Ingredient: Methylprednisolone Sodium Succinate

Methylprednisolone Sodium Succinate is available for IV or IM administration as:

SOLU-MEDROL sterile powder 500 mg

I. Each powder vial contains:

Methylprednisolone (as methylprednisolone sodium succinate) 500 mg - Sodium biphosphate monohydrate - Dibasic sodium phosphate

II. Each diluent vial (7.8 mL) contains:

Benzyl alcohol 70.2 mg - Water for Injection.

SOLU-MEDROL sterile powder 1000 mg

I. Each powder vial contains:

Methylprednisolone (as methylprednisolone sodium succinate) 1000 mg - Sodium biphosphate monohydrate - Dibasic sodium phosphate

II. Each diluent vial (15.6 mL) contains:

Benzyl alcohol 140.4 mg - Water for Injection.

3. PHARMACEUTICAL FORM

Sterile powder for injection

4. CLINICAL PARTICULARS

4.1 Therapeutic Indications

Glucocorticoids should only be considered as a purely symptomatic treatment, unless in case of some endocrine disorders, where they are used as substitution treatment.

ANTI-INFLAMMATORY TREATMENT

Rheumatic Disorders (as adjunctive therapy for short-term administration in the management of an acute episode or exacerbation)

- 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 non-specific tenosynovitis;
- acute gouty arthritis;
- psoriatic arthritis;
- ankylosing spondylitis.

Collagen Diseases (during an exacerbation or as maintenance therapy in selected cases)

- systemic lupus erythematosus;
- acute rheumatic carditis;
- systemic dermatomyositis (polymyositis);
- polyarteritis nodosa;
- Goodpasture's syndrome.

Dermatologic Diseases

- pemphigus;
- severe erythema multiforme (Stevens-Johnson syndrome);
- exfoliative dermatitis;
- bullous dermatitis herpetiformis;
- severe seborrheic dermatitis;
- severe psoriasis;
- mycosis fungoides;
- urticaria.

Allergic States (to control severe or incapacitating allergic conditions intractable to adequate trials of conventional treatment)

- bronchial asthma;
- contact dermatitis;
- atopic dermatitis;
- serum sickness;
- drug hypersensitivity reactions;
- urticarial transfusion reactions;
- acute non-infectious laryngeal edema (epinephrine is the drug of first choice).

Ophthalmic Diseases (severe acute and chronic allergic and inflammatory processes involving the eye)

- herpes zoster ophthalmicus;
- iritis, iridocyclitis;
- chorioretinitis;
- diffuse posterior uveitis and choroiditis;
- optic neuritis;
- sympathetic ophthalmia.

Gastrointestinal Diseases (to manage critical periods of the disease)

- ulcerative colitis (systemic therapy);
- Crohn's disease (systemic therapy).

Respiratory Diseases

- symptomatic pulmonary sarcoidosis;
- berylliosis;
- fulminating or disseminated pulmonary tuberculosis when used concurrently with appropriate anti-tuberculous chemotherapy;
- Loeffler's syndrome not manageable by other means;
- aspiration pneumonitis.

Edematous States

- To induce diuresis or remission of proteinuria in the nephrotic syndrome, without uremia of the idiopathic type or that due to lupus erythematosus.

IMMUNOSUPPRESSIVE TREATMENT

Organ Transplantation

TREATMENT OF HEMATOLOGICAL AND ONCOLOGICAL DISORDERS

Hematologic Disorders

- acquired (autoimmune) hemolytic anemia;
- idiopathic thrombocytopenia purpura in adults (IV only; IM Administration is contraindicated);
- secondary thrombocytopenia in adults;
- erythroblastopenia (RBC anemia);
- congenital (erythroid) hypoplastic anemia.

Oncological Diseases

For palliative management of:

- leukemias and lymphomas in adults;
- acute leukemia of childhood.

TREATMENT OF SHOCK STATES

Shock secondary to adrenocortical insufficiency or shock unresponsive to conventional therapy when adrenal cortical insufficiency may be present. (Hydrocortisone is generally the drug of choice. When mineralocorticoid activity is undesirable, methylprednisolone may be preferred.)

Hemorrhagic, traumatic and surgical shock unresponsive to standard therapy.

Although there are no well controlled (double-blind placebo) clinical trials, data from experimental animal models indicate that SOLU-MEDROL may be useful in shock states in which standard therapy e.g., fluid replacement has not been effective.

OTHERS

Nervous System

- cerebral edema from tumour – primary or metastatic and/or associated with surgical or radiation therapy or head trauma;
- acute exacerbations of multiple sclerosis;
- acute spinal cord injury. The treatment should begin within 8 hours of injury.

Tuberculous meningitis with subarachnoid block or impending block when used concurrently with appropriate anti-tuberculosis chemotherapy.

Trichinosis with neurologic or myocardial involvement.

Prevention of nausea and vomiting associated with cancer chemotherapy.

ENDOCRINE DISORDERS

- primary or secondary adrenocortical insufficiency;
- acute adrenocortical insufficiency;
- for these indications, the drugs of choice are hydrocortisone or cortisone. Synthetic analogues can be used in certain circumstances if they are combined with mineralocorticoids;
- preoperatively and in the event of serious trauma or illness, in patients with known adrenal insufficiency or when adrenocortical reserve is doubtful;

- congenital adrenal hyperplasia;
- non-suppurative thyroiditis;
- hypercalcemia associated with cancer.

4.2 Posology and Method of Administration

Methylprednisolone sodium succinate may be administered by intravenous (IV) injection or infusion, or by intramuscular (IM) injection. The preferred method for initial emergency use is IV injection. Dosage may be reduced for infants and children but should be selected based on the severity of the condition and the response of the patient rather than on the age or weight of the patient. The pediatric dosage should not be less than 0.5 mg/kg every 24 hours.

Dosage requirements are variable and must be individualized on the basis of the disease under treatment, its severity and the response of the patient over the entire duration of treatment. A risk/benefit decision must be made in each individual case on an ongoing basis.

The lowest possible dose of corticosteroid should be used to control the condition under treatment for the minimum period. The proper maintenance dosage should be determined by decreasing the initial drug dosage in small decrements at appropriate time intervals until the lowest dosage, which will maintain an adequate clinical response, is reached.

If after long-term therapy the drug is to be stopped, it needs to be withdrawn gradually rather than abruptly (see section 4.4 **Special Warnings and Precautions for Use**).

Following the initial emergency period, consideration should be given to employing a longer acting injectable preparation or an oral preparation.

Table 1. Recommended dosages for methylprednisolone sodium succinate	
<u>Indication</u>	<u>Dosage</u>
Adjunctive therapy in life-threatening conditions	Administer 30 mg/kg IV over a period of at least 30 minutes. Dose may be repeated every 4 to 6 hours for up to 48 hours.
Rheumatic disorders unresponsive to standard therapy (or during exacerbation episodes)	Administer either regimen as IV pulse dosing over at least 30 minutes. The regimen may be repeated if improvement has not occurred within a week after therapy, or as the patient's condition dictates. 1 g/day for 1 to 4 days, <u>or</u> 1 g/month for 6 months.
Systemic lupus erythematosus unresponsive to standard therapy (or during exacerbation episodes)	Administer 1 g/day for 3 days as IV pulse dosing over at least 30 minutes. The regimen may be repeated if improvement has not occurred within a week after therapy, or as the patient's condition dictates.
Multiple sclerosis unresponsive to standard therapy (or during exacerbation episodes)	Administer 500 mg/day or 1 g/day for 3 or 5 days as IV pulse dosing over at least 30 minutes. The regimen may be repeated if improvement has not occurred within a week after therapy, or as the patient's condition dictates.
Edematous states, such as glomerulonephritis or lupus nephritis, unresponsive to standard therapy (or during exacerbation episodes)	Administer either regimen as IV pulse dosing over at least 30 minutes. The regimen may be repeated if improvement has not occurred within 1 week after therapy, or as the patient's condition dictates. 30 mg/kg every other day for 4 days, <u>or</u> 1 g/day for 3, 5 or 7 days.

Table 1. Recommended dosages for methylprednisolone sodium succinate	
Prevention of nausea and vomiting associated with cancer chemotherapy	For mild to moderately emetogenic chemotherapy: Administer 250 mg IV over at least 5 minutes 1 hour before start of chemotherapy. Repeat dose of methylprednisolone at the initiation of chemotherapy and at the time of discharge. A chlorinated phenothiazine may also be used with the first dose of methylprednisolone for increased effect. For severely emetogenic chemotherapy: Administer 250 mg IV over at least 5 minutes with appropriate doses of metoclopramide or a butyrophenone 1 hour before start of chemotherapy. Repeat dose of methylprednisolone at the initiation of chemotherapy and at the time of discharge.
Acute spinal cord injury	Treatment should begin within 8 hours of injury: For patients initiated on treatment within 3 hours of injury: Administer 30 mg/kg as an IV bolus over a 15-minute period, followed by a 45-minute pause, and then a continuous IV infusion of 5.4 mg/kg/h for 23 hours. For patients initiated on treatment within 3 to 8 hours of injury: Administer 30 mg/kg as an IV bolus over a 15-minute period, followed by a 45-minute pause, and then a continuous IV infusion of 5.4 mg/kg/h for 47 hours. There should be a separate intravenous site for the infusion pump.
As adjunctive therapy in other indications	Initial dose will vary from 10 to 500 mg IV, depending on the clinical condition. Larger doses may be required for short-term management of severe, acute conditions. Initial doses up to 250 mg should be administered IV over a period of at least 5 minutes, while larger doses should be administered over at least 30 minutes. Subsequent doses may be administered IV or IM at intervals dictated by the patient's response and clinical condition.

To avoid compatibility and stability problems, it is recommended that methylprednisolone sodium succinate be administered separately from other drugs whenever possible, as either IV push, through an IV medication chamber, as an IV “piggy-back” solution, or via an infusion pump (see section 6.6 **Special Instructions for Use/Handling**).

NOTE: Some of the methylprednisolone sodium succinate formulations come with a diluent that contains benzyl alcohol (see section 4.4 **Special Warnings and Precautions for Use, Use in Children**). The amount of benzyl alcohol per mL is 9 mg.

4.3 Contraindications

Methylprednisolone sodium succinate is contraindicated:

- in patients who have systemic fungal infections;
- in patients with known hypersensitivity to methylprednisolone or any component of the formulation;
- for use by the intrathecal route of administration;
- for use by the epidural route of administration.

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

4.4 Special Warnings and Precautions for Use

Immunosuppressant Effects/Increased Susceptibility to Infections

Corticosteroids may increase susceptibility to infection, may mask some signs of infection, exacerbate existing infections, increase the risk of reactivation or exacerbation of latent infections and new infections may appear during their use. There may be decreased resistance and inability to localize infection when corticosteroids are used. Infections with any pathogen including viral, bacterial, fungal, protozoan or helminthic organisms, in any location in the body, may be associated with the use of corticosteroids alone or in combination with other immunosuppressive agents that affect cellular or humoral immunity, or neutrophil function. These infections may be mild, but can be severe and at times fatal. With increasing doses of corticosteroids, the rate of occurrence of infectious complications increases.

Monitor for the development of infection and consider withdrawal of corticosteroids or dosage reduction as needed.

Persons who are on drugs which suppress the immune system are more susceptible to infections than healthy individuals. Chicken pox and measles, for example, can have a more serious or even fatal course in non-immune children or adults on corticosteroids.

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. Indicated immunization procedures may be undertaken in patients receiving non-immunosuppressive doses of corticosteroids.

The use of corticosteroids in active tuberculosis should be restricted to those cases of fulminating or disseminated tuberculosis in which the corticosteroid is used for the management of the disease in conjunction with appropriate anti-tuberculosis regimen.

If corticosteroids are indicated in patients with latent tuberculosis or tuberculin reactivity, close observation is necessary as reactivation of the disease may occur. During prolonged corticosteroid therapy, these patients should receive chemoprophylaxis.

Kaposi's sarcoma has been reported to occur in patients receiving corticosteroid therapy. Discontinuation of corticosteroids may result in clinical remission.

The role of corticosteroids in septic shock has been controversial, with early studies reporting both beneficial and detrimental effects. More recently, supplemental corticosteroids have been suggested to be beneficial in patients with established septic shock who exhibit adrenal insufficiency. However, their routine use in septic shock is not recommended. A systematic review of short-course, high-dose corticosteroids did not support their use. However, meta-analyses, and a review suggest that longer courses (5-11 days) of low-dose corticosteroids might reduce mortality, especially in patients with vasopressor-dependent septic shock.

Immune System Effects

Allergic reactions may occur. Because rare instances of skin reactions and anaphylactic/anaphylactoid reactions have occurred in patients receiving corticosteroid therapy, appropriate precautionary measures should be taken prior to administration, especially when the patient has a history of allergy to any drug.

Endocrine Effects

In patients on corticosteroid therapy subjected to unusual stress, increased dosage of rapidly acting corticosteroids before, during and after the stressful situation is indicated.

Pharmacologic doses of corticosteroids administered for prolonged periods may result in hypothalamic-pituitary-adrenal (HPA) suppression (secondary adrenocortical insufficiency). The degree and duration of adrenocortical insufficiency produced is variable among patients and depends on the dose, frequency, time of administration, and duration of glucocorticoid therapy. This effect may be minimized by use of alternate-day therapy.

In addition, acute adrenal insufficiency leading to a fatal outcome may occur if glucocorticoids are withdrawn abruptly.

Drug-induced secondary adrenocortical insufficiency may therefore be minimized by gradual reduction of dosage. This type of relative insufficiency may persist for months after discontinuation of therapy; therefore, in any situation of stress occurring during that period, hormone therapy should be reinstituted.

A steroid “withdrawal syndrome,” seemingly unrelated to adrenocortical insufficiency, may also occur following abrupt discontinuance of glucocorticoids. This syndrome includes symptoms such as: anorexia, nausea, vomiting, lethargy, headache, fever, joint pain, desquamation, myalgia, weight loss, and/or hypotension. These effects are thought to be due to the sudden change in glucocorticoid concentration rather than to low corticosteroid levels.

Because glucocorticoids can produce or aggravate Cushing’s syndrome, glucocorticoids should be avoided in patients with Cushing’s disease.

There is an enhanced effect of corticosteroids on patients with hypothyroidism.

Metabolism and Nutrition

Corticosteroids, including methylprednisolone, can increase blood glucose, worsen pre-existing diabetes, and predispose those on long-term corticosteroid therapy to diabetes mellitus.

Psychiatric Effects

Psychic derangements may appear when corticosteroids are used, ranging from euphoria, insomnia, mood swings, personality changes, and severe depression to frank psychotic manifestations. Also, existing emotional instability or psychotic tendencies may be aggravated by corticosteroids.

Potentially severe psychiatric adverse reactions may occur with systemic steroids. Symptoms typically emerge within a few days or weeks of starting treatment. Most reactions recover after either dose reduction or withdrawal, although specific treatment may be necessary. Psychological effects have been reported upon withdrawal of corticosteroids; the frequency is unknown. Patients/caregivers should be encouraged to seek medical attention if psychological symptoms develop in the patient, especially if depressed mood or suicidal ideation is suspected. Patients/caregivers should be alert to possible psychiatric disturbances that may occur either during or immediately after dose tapering/withdrawal of systemic steroids.

Nervous System Effects

Corticosteroids should be used with caution in patients with seizure disorders.

Corticosteroids should be used with caution in patients with myasthenia gravis. (Also see myopathy statement in Musculoskeletal Effects section)

Although controlled clinical trials have shown corticosteroids to be effective in speeding the resolution of acute exacerbations of multiple sclerosis, they do not show that corticosteroids affect the ultimate outcome or natural history of the disease. The studies do show that relatively high doses of corticosteroids are necessary to demonstrate a significant effect.

Severe medical events have been reported in association with the intrathecal/epidural routes of administration (see section 4.8 **Undesirable Effects**).

There have been reports of epidural lipomatosis in patients taking corticosteroids, typically with long-term use at high doses.

Ocular Effects

Corticosteroids should be used cautiously in patients with ocular herpes simplex because of possible corneal perforation.

Prolonged use of corticosteroids may produce posterior subcapsular cataracts and nuclear cataracts (particularly in children), exophthalmos, or increased intraocular pressure, which may result in glaucoma with possible damage to the optic nerves. Establishment of secondary fungal and viral infections of the eye may also be enhanced in patients receiving glucocorticoids.

Corticosteroid therapy has been associated with central serous chorioretinopathy, which may lead to retinal detachment.

Cardiac Effects

Adverse effects of glucocorticoids on the cardiovascular system, such as dyslipidemia and hypertension, may predispose treated patients with existing cardiovascular risk factors to additional cardiovascular effects, if high doses and prolonged courses are used. Accordingly, corticosteroids should be employed judiciously in such patients and attention should be paid to risk modification and additional cardiac monitoring if needed. Low dose and alternate day therapy may reduce the incidence of complications in corticosteroid therapy.

There are reports of cardiac arrhythmias, and/or circulatory collapse, and/or cardiac arrest following the rapid administration of large intravenous doses of methylprednisolone sodium succinate (more than 0.5 g administered over a period of less than 10 minutes). Bradycardia has been reported during or after the administration of large doses of methylprednisolone sodium succinate, and may be unrelated to the speed or duration of infusion.

Systemic corticosteroids should be used with caution, and only if strictly necessary, in cases of congestive heart failure.

Vascular Effects

Thrombosis including venous thromboembolism has been reported to occur with corticosteroids. As a result corticosteroids should be used with caution in patients who have or may be predisposed to thromboembolic disorders.

Steroids should be used with caution in patients with hypertension.

Gastrointestinal Effects

High doses of corticosteroids may produce acute pancreatitis.

There is no universal agreement on whether corticosteroids *per se* are responsible for peptic ulcers encountered during therapy; however, glucocorticoid therapy may mask the symptoms of peptic ulcer so that perforation or hemorrhage may occur without significant pain. Glucocorticoid therapy may mask peritonitis or other signs or symptoms associated with gastrointestinal disorders such as perforation, obstruction or pancreatitis. In combination with NSAIDs, the risk of developing gastrointestinal ulcers is increased.

Corticosteroids should be used with caution in patients with non-specific ulcerative colitis if there is a probability of impending perforation, abscess, or other pyogenic infection, diverticulitis, fresh intestinal anastomoses, or active or latent peptic ulcer.

Hepatobiliary Effects

Drug induced liver injury such as acute hepatitis can result from cyclical pulsed IV methylprednisolone (usually at doses of 1 g/day). The time to onset of acute hepatitis can be several weeks or longer. Resolution of the adverse event has been observed after treatment was discontinued.

Musculoskeletal Effects

An acute myopathy has been reported with the use of high doses of corticosteroids, most often occurring in patients with disorders of neuromuscular transmission (e.g., myasthenia gravis), or in patients receiving concomitant therapy with anticholinergics, such as neuromuscular blocking drugs (e.g., pancuronium). This acute myopathy is generalized, may involve ocular and respiratory muscles, and may result in quadriplegia. Elevations of creatine kinase may occur. Cases of rhabdomyolysis have been reported. Clinical improvement or recovery after stopping corticosteroids may require weeks to years.

Osteoporosis is a common but infrequently recognized adverse effect associated with a long-term use of large doses of glucocorticoid.

Renal and Urinary Disorders

Caution is required in patients with systemic sclerosis because an increased incidence of scleroderma renal crisis has been observed with corticosteroids, including methylprednisolone.

Corticosteroids should be used with caution in patients with renal insufficiency.

Investigations

Average and large doses of hydrocortisone or cortisone can cause elevation of blood pressure, salt and water retention, and increased excretion of potassium. These effects are less likely to occur with the synthetic derivatives except when used in large doses. Dietary salt restriction and potassium supplementation may be necessary. All corticosteroids increase calcium excretion.

Injury, Poisoning and Procedural Complications

Systemic corticosteroids are not indicated for, and therefore, should not be used to treat, traumatic brain injury; a multicenter study revealed an increased mortality at 2 weeks and 6 months after injury in patients administered methylprednisolone sodium succinate compared to placebo. A causal association with methylprednisolone sodium succinate treatment has not been established.

Other

Since complications of treatment with glucocorticoids are dependent on the size of the dose and the duration of treatment, a risk/benefit decision must be made in each individual case as to dose and duration of treatment as to whether daily or intermittent therapy should be used.

The lowest possible dose of corticosteroid should be used to control the condition under treatment and when reduction in dosage is possible, the reduction should be gradual.

Aspirin and nonsteroidal anti-inflammatory agents should be used cautiously in conjunction with corticosteroids.

Pheochromocytoma crisis, which can be fatal, has been reported after administration of systemic corticosteroids. Corticosteroids should only be administered to patients with suspected or identified pheochromocytoma after an appropriate risk/benefit evaluation.

In post marketing experience tumor lysis syndrome (TLS) has been reported in patients with malignancies, including hematological malignancies and solid tumors, following the use of systemic corticosteroids alone or in combination with other chemotherapeutic agents. Patients at high risk of TLS, such as patients with tumors that have a high proliferative rate, high tumor burden and high sensitivity to cytotoxic agents, should be monitored closely and appropriate precautions should be taken.

Use in Children

The following statement applies only when benzyl alcohol is included in the diluent:

The preservative benzyl alcohol has been associated with serious adverse events, including the “gasping syndrome”, and death in pediatric patients. Although normal therapeutic doses of this product ordinarily deliver amounts of benzyl alcohol that are substantially lower than those reported in association with the “gasping syndrome”, the minimum amount of benzyl alcohol at which toxicity may occur is not known. The risk of benzyl alcohol toxicity depends on the quantity administered and the liver and kidneys’ capacity to detoxify the chemical. Premature and low-birth weight infants may be more likely to develop toxicity.

Growth and development of infants and children on prolonged corticosteroid therapy should be carefully observed.

Growth may be suppressed in children receiving long-term, daily, divided-dose glucocorticoid therapy and use of such regimen should be restricted to the most urgent indications. Alternate-day glucocorticoid therapy usually avoids or minimizes this side effect.

Infants and children on prolonged corticosteroid therapy are at special risk from raised intracranial pressure.

High doses of corticosteroids may produce pancreatitis in children.

Hypertrophic cardiomyopathy may develop after administration of methylprednisolone to prematurely born infants, therefore appropriate diagnostic evaluation and monitoring of cardiac function and structure should be performed.

4.5 Interaction with Other Medicinal Products and Other Forms of Interaction

Methylprednisolone is a cytochrome P450 enzyme (CYP) substrate and is mainly metabolized by the CYP3A4 enzyme. CYP3A4 is the dominant enzyme of the most abundant CYP subfamily in the liver of adult humans. It catalyzes 6 β -hydroxylation of steroids, the essential Phase I metabolic step for both endogenous and synthetic corticosteroids. Many other compounds are also substrates of CYP3A4, some of which (as well as other drugs) have been shown to alter glucocorticoid metabolism by induction (upregulation) or inhibition of the CYP3A4 enzyme.

CYP3A4 INHIBITORS - Drugs that inhibit CYP3A4 activity generally decrease hepatic clearance and increase the plasma concentration of CYP3A4 substrate medications, such as methylprednisolone. In the presence of a CYP3A4 inhibitor, the dose of methylprednisolone may need to be titrated to avoid steroid toxicity.

CYP3A4 INDUCERS - Drugs that induce CYP3A4 activity generally increase hepatic clearance, resulting in decreased plasma concentration of medications that are substrates for CYP3A4.

Coadministration may require an increase in methylprednisolone dosage to achieve the desired result.

CYP3A4 SUBSTRATES - In the presence of another CYP3A4 substrate, the hepatic clearance of methylprednisolone may be affected, with corresponding dosage adjustments required. It is possible that adverse events associated with the use of either drug alone may be more likely to occur with coadministration.

Co-treatment with CYP3A inhibitors, including cobicistat-containing products, is expected to increase the risk of systemic side-effects. The combination should be avoided unless the benefit outweighs the increased risk of systemic corticosteroid side-effects, in which case patients should be monitored for systemic corticosteroid side-effects.

NON-CYP3A4-MEDIATED EFFECTS – Other interactions and effects that occur with methylprednisolone are described in Table 2 below.

Table 2 provides a list and descriptions of the most common and/or clinically important drug interactions or effects with methylprednisolone.

Table 2. Important drug or substance interactions/effects with methylprednisolone

Drug Class or Type DRUG or SUBSTANCE	Interaction/Effect
Antibacterial - ISONIAZID	CYP3A4 INHIBITOR. In addition, there is a potential effect of methylprednisolone to increase the acetylation rate and clearance of isoniazid.
Antibiotic, Antitubercular - RIFAMPIN	CYP3A4 INDUCER.
Anticoagulants (oral) - VITAMIN K ANTAGONISTS	The effect of methylprednisolone on vitamin K antagonists (eg, warfarin, acenocoumarol, fluindione) is variable. There are reports of enhanced as well as diminished effects of these anticoagulants when given concurrently with corticosteroids. Therefore, coagulation indices should be monitored to maintain the desired anticoagulant effects.
Anticonvulsants - CARBAMAZEPINE	CYP3A4 INDUCER (and SUBSTRATE).
Anticonvulsants - PHENOBARBITAL - PHENYTOIN	CYP3A4 INDUCERS.
Anticholinergics - NEUROMUSCULAR BLOCKERS	Corticosteroids may influence the effect of anticholinergics. 1) An acute myopathy has been reported with the concomitant use of high doses of corticosteroids and anticholinergics, such as neuromuscular blocking drugs (see section 4.4 Special Warnings and Precautions for Use , Musculoskeletal Effects, for additional information). 2) Antagonism of the neuromuscular blocking effects of pancuronium and vecuronium has been reported in patients taking corticosteroids. This interaction may be expected with all competitive neuromuscular blockers.
Anticholinesterases	Steroids may reduce the effects of anticholinesterases in myasthenia gravis.
Antidiabetics	Because corticosteroids may increase blood glucose concentrations, dosage adjustments of antidiabetic agents may be required.
Antiemetic - APREPITANT - FOSAPREPITANT	CYP3A4 INHIBITORS (and SUBSTRATES).
Antifungal - ITRACONAZOLE - KETOCONAZOLE	CYP3A4 INHIBITORS (and SUBSTRATES).

Drug Class or Type DRUG or SUBSTANCE	Interaction/Effect
Antivirals - HIV-PROTEASE INHIBITORS	CYP3A4 INHIBITORS (and SUBSTRATES). 1) Protease inhibitors, such as indinavir and ritonavir, may increase plasma concentrations of corticosteroids. 2) Corticosteroids may induce the metabolism of HIV-protease inhibitors resulting in reduced plasma concentrations.
Aromatase inhibitors - AMINOGLUTETHIMIDE	Aminoglutethimide-induced adrenal suppression may exacerbate endocrine changes caused by prolonged glucocorticoid treatment.
Calcium channel blocker - DILTIAZEM	CYP3A4 INHIBITOR (and SUBSTRATE).
Contraceptives (oral) - ETHINYLESTRADIOL/ NORETHINDRONE	CYP3A4 INHIBITOR (and SUBSTRATE).
- GRAPEFRUIT JUICE	CYP3A4 INHIBITOR.
Immunosuppressant - CYCLOSPORINE	CYP3A4 INHIBITOR (and SUBSTRATE). 1) Mutual inhibition of metabolism occurs with concurrent use of cyclosporine and methylprednisolone, which may increase the plasma concentrations of either or both drugs. Therefore, it is possible that adverse events associated with the use of either drug alone may be more likely to occur upon coadministration. 2) Convulsions have been reported with concurrent use of methylprednisolone and cyclosporine.
Immunosuppressant - CYCLOPHOSPHAMIDE - TACROLIMUS	CYP3A4 SUBSTRATES.
Macrolide antibacterial - CLARITHROMYCIN - ERYTHROMYCIN	CYP3A4 INHIBITORS (and SUBSTRATES).
Macrolide antibacterial - TROLEANDOMYCIN	CYP3A4 INHIBITOR.
NSAIDs (nonsteroidal anti-inflammatory drugs)- high-dose ASPIRIN (acetylsalicylic acid)	1) There may be increased incidence of gastrointestinal bleeding and ulceration when corticosteroids are given with NSAIDs. 2) Methylprednisolone may increase the clearance of high-dose aspirin, which can lead to decreased salicylate serum levels. Discontinuation of methylprednisolone treatment can lead to raised salicylate serum levels, which could lead to an increased risk of salicylate toxicity.
Potassium depleting agents	When corticosteroids are administered concomitantly with potassium depleting agents (i.e., diuretics), patients should be observed closely for development of hypokalemia. There is also an increased risk of hypokalemia with concurrent use of corticosteroids with amphotericin B, xanthines, or beta2 agonists.

Incompatibilities

To avoid compatibility and stability problems, it is recommended that methylprednisolone sodium succinate be administered separately from other compounds that are administered via the IV route of administration. Drugs that are physically incompatible in solution with methylprednisolone sodium succinate include but are not limited to: allopurinol sodium, doxapram hydrochloride, tigecycline, diltiazem hydrochloride calcium gluconate, vecuronium bromide, rocuronium bromide, cisatracurium besylate, glycopyrrolate, propofol (see section 6.2 **Incompatibilities** for additional information).

4.6 Fertility, Pregnancy and Lactation

Fertility

Corticosteroids have been shown to impair fertility in animal studies (see section 5.3 **Preclinical Safety Data**).

Pregnancy

Animal studies have shown that corticosteroids, when administered to the mother at high doses, may cause fetal malformations. However, corticosteroids do not appear to cause congenital anomalies when given to pregnant women. Since adequate human reproductive studies have not been done with methylprednisolone sodium succinate, this medicinal product should be used during pregnancy only after a careful assessment of the benefit-risk ratio to the mother and fetus.

Some corticosteroids readily cross the placenta. One retrospective study found an increased incidence of low-birth weights in infants born of mothers receiving corticosteroids. In humans, the risk of low birth weight appears to be dose related and may be minimized by administering lower corticosteroid doses. Infants born to mothers, who have received substantial doses of corticosteroids during pregnancy must be carefully observed and evaluated for signs of adrenal insufficiency, although neonatal adrenal insufficiency appears to be rare in infants who were exposed *in utero* to corticosteroids.

There are no known effects of corticosteroids on labor and delivery.

Cataracts have been observed in infants born to mothers treated with long-term corticosteroids during pregnancy.

The following statement applies only when benzyl alcohol is included in the diluent:

Benzyl alcohol can cross the placenta (see section 4.4 **Special Warnings and Precautions for Use**).

Lactation

Corticosteroids are excreted in breast milk.

Corticosteroids distributed into breast milk may suppress growth and interfere with endogenous glucocorticoid production in nursing infants. This medicinal product should be used during breast-feeding only after a careful assessment of the benefit-risk ratio to the mother and infant.

4.7 Effects on Ability to Drive and Use Machines

The effect of corticosteroids on the ability to drive or use machinery has not been systematically evaluated. Undesirable effects, such as dizziness, vertigo, visual disturbances, and fatigue are possible after treatment with corticosteroids. If affected, patients should not drive or operate machinery.

4.8 Undesirable Effects

The following adverse reactions have been reported with the following contraindicated routes of administration: Intrathecal/Epidural: Arachnoiditis, functional gastrointestinal disorder/bladder dysfunction, headache, meningitis, paraparesis/paraplegia, seizure, sensory disturbance.

Table 3. ADRs by SOC and CIOMS frequency category listed in order of decreasing medical seriousness within each frequency category and SOC

System Organ Class	Very Common ≥1/10	Common ≥1/100 to <1/10	Uncommon ≥1/1,000 to <1/100	Rare ≥1/10,000 to <1/1,000	Very Rare <1/10,000	Frequency Not Known (cannot be estimated from the available data)
Infections and infestations						Opportunistic infection, Infection, Peritonitis [#]
Blood and lymphatic system disorders						Leukocytosis
Immune system disorders						Drug hypersensitivity, Anaphylactic reaction, Anaphylactoid reaction
Endocrine disorders						Cushingoid, Hypothalamic pituitary adrenal axis suppression, Steroid withdrawal syndrome
Metabolism and nutrition disorders						Metabolic acidosis, Sodium retention, Fluid retention, Alkalosis hypokalaemic, Dyslipidaemia, Glucose tolerance impaired, Increased insulin requirement (or oral hypoglycemic agents in diabetics), Lipomatosis, Increased appetite (which may result in Weight increased)
Psychiatric disorders						Affective disorder (including Depressed mood, Euphoric mood, Affect lability, Drug dependence, Suicidal ideation), Psychotic disorder (including Mania, Delusion, Hallucination, and Schizophrenia), Mental disorder, Personality change, Confusional state, Anxiety, Mood swings, Abnormal behaviour, Insomnia,

System Organ Class	Very Common ≥1/10	Common ≥1/100 to <1/10	Uncommon ≥1/1,000 to <1/100	Rare ≥1/10,000 to <1/1,000	Very Rare <1/10,000	Frequency Not Known (cannot be estimated from the available data)
						Irritability
Nervous system disorders						Epidural lipomatosis, Intracranial pressure increased (with Papilloedema [Benign intracranial hypertension]), Seizure, Amnesia, Cognitive disorder, Dizziness, Headache
Eye disorders						Chorioretinopathy, Cataract, Glaucoma, Exophthalmos
Ear and labyrinth disorders						Vertigo
Cardiac disorders						Cardiac failure congestive (in susceptible patients), Arrhythmia
Vascular disorders						Thrombosis, Hypertension, Hypotension, Flushing
Respiratory, thoracic and mediastinal disorders						Pulmonary embolism, Hiccups
Gastrointestinal disorders						Peptic ulcer (with possible Peptic ulcer perforation and Peptic ulcer haemorrhage), Intestinal perforation, Gastric haemorrhage, Pancreatitis, Oesophagitis ulcerative, Oesophagitis, Abdominal distension, Abdominal pain, Diarrhoea, Dyspepsia, Nausea
Hepatobiliary disorders						Hepatitis [†]
Skin and subcutaneous tissue disorders						Angioedema, Hirsutism, Petechiae, Ecchymosis, Skin atrophy, Erythema, Hyperhidrosis, Skin striae, Rash, Pruritus, Urticaria, Acne, Skin hypopigmentation,

System Organ Class	Very Common ≥1/10	Common ≥1/100 to <1/10	Uncommon ≥1/1,000 to <1/100	Rare ≥1/10,000 to <1/1,000	Very Rare <1/10,000	Frequency Not Known (cannot be estimated from the available data)
						Panniculitis
Musculoskeletal and connective tissue disorders						Muscular weakness, Myalgia, Myopathy, Rhabdomyolysis, Muscle atrophy, Osteoporosis, Osteonecrosis, Pathological fracture, Neuropathic arthropathy, Arthralgia, Growth retardation
Reproductive system and breast disorders						Menstruation irregular
General disorders and administration site conditions						Impaired healing, Oedema peripheral, Fatigue, Malaise, Injection site reaction
Investigations						Intraocular pressure increased, Carbohydrate tolerance decreased, Blood potassium decreased, Urine calcium increased, Alanine aminotransferase increased, Aspartate aminotransferase increased, Blood alkaline phosphatase increased, Blood urea increased, Suppression of reactions to skin tests*
Injury, poisoning and procedural complications						Spinal compression fracture, Tendon rupture

The following adverse reactions have been reported with the following contraindicated routes of administration:
 Intrathecal/Epidural: Arachnoiditis, functional gastrointestinal disorder/bladder dysfunction, headache, meningitis, paraparesis/paraplegia, seizure, sensory disturbance. The frequency of these adverse reactions is not known.

* Not a MedDRA PT

† Hepatitis has been reported with IV administration (see section 4.4 **Special Warnings and Precautions for Use**).

Peritonitis may be the primary presenting sign or symptom of a gastrointestinal disorder such as perforation, obstruction or pancreatitis (see section 4.4 **Special Warnings and Precautions for Use**).

4.9 Overdose

There is no clinical syndrome of acute overdosage with corticosteroids.

Reports of acute toxicity and/or death following overdosage of corticosteroids are rare. In the event of overdosage, no specific antidote is available; treatment is supportive and symptomatic.

Methylprednisolone is dialyzable.

5. PHARMACOLOGICAL PROPERTIES

5.1 Pharmacodynamic Properties

Methylprednisolone is a potent anti-inflammatory steroid. It has greater anti-inflammatory potency than prednisolone and less tendency than prednisolone to induce sodium and water retention.

Methylprednisolone sodium succinate has the same metabolic and anti-inflammatory actions as methylprednisolone. When given parenterally and in equimolar quantities, the two compounds are equivalent in biologic activity. The relative potency of methylprednisolone sodium succinate and hydrocortisone sodium succinate, as indicated by depression of eosinophil count, following intravenous administration, is at least four to one. This is in good agreement with the relative oral potency of methylprednisolone and hydrocortisone.

Methylprednisolone sodium succinate has been investigated for acute spinal cord injury in two randomized, double-blind, comparative National Acute Spinal Cord Injury Studies (NASCIS 2 and 3). The effect of high dose methylprednisolone sodium succinate given as initial bolus of 30 mg/kg by IV for 15 minutes followed 45 minutes later by a continuous infusion of 5.4 mg/kg/hour for 24 hours was significant on neurologic recovery when given to patients within 8 hours from injury (NASCIS 2) and motor recovery was higher for those patients initiated within 3 to 8 hours from injury and treated with the same regimen for 48 hours (NASCIS 3).

5.2 Pharmacokinetic Properties

Methylprednisolone pharmacokinetics is linear, independent of route of administration.

Absorption:

After a 40 mg intramuscular dose of methylprednisolone sodium succinate to fourteen healthy adult male volunteers, the average peak concentration of 454 ng/mL was achieved at 1 hour. At 12 hours, the methylprednisolone plasma concentration has declined to 31.9 ng/mL. No methylprednisolone was detected 18 hours after dosing. Based on area-under-the-time-concentration curve, an indication of total drug absorbed, intramuscular methylprednisolone sodium succinate was found to be equivalent to the same dose administered intravenously.

Results of a study demonstrated that the sodium succinate ester of methylprednisolone is rapidly and extensively converted to the active methylprednisolone moiety after all routes of administration. Extent of absorption of free methylprednisolone following IV and IM administrations were found to be equivalent and significantly greater than those following administration of the oral solution and oral methylprednisolone tablets. Since the extent of methylprednisolone absorbed following the IV and IM treatment was equivalent in spite of the greater amount of the hemisuccinate ester reaching the general circulation after IV administration, it appears that the ester is converted in the tissue after IM injection with subsequent absorption as free methylprednisolone.

Distribution:

Methylprednisolone is widely distributed into the tissues, crosses the blood-brain barrier, and is secreted in breast milk. Its apparent volume of distribution is approximately 1.4 L/kg. The plasma protein binding of methylprednisolone in humans is approximately 77%.

Metabolism:

In humans, methylprednisolone is metabolized in the liver to inactive metabolites; the major ones are 20 α -hydroxymethylprednisolone and 20 β -hydroxymethylprednisolone.

Metabolism in the liver occurs primarily via the CYP3A4. (For a list of drug interactions based on CYP3A4-mediated metabolism, see section 4.5 **Interaction with Other Medicinal Products and Other Forms of Interaction**).

Methylprednisolone, like many CYP3A4 substrates, may also be a substrate for the ATP-binding cassette (ABC) transport protein p-glycoprotein, influencing tissue distribution and interactions with other medicines.

Elimination:

The mean elimination half-life for total methylprednisolone is in the range of 1.8 to 5.2 hours. Total clearance is approximately 5 to 6 mL/min/kg.

No dosing adjustments are necessary in renal failure. Methylprednisolone is hemodialyzable.

5.3 Preclinical Safety Data

Based on conventional studies of safety pharmacology and repeated-dose toxicity no unexpected hazards were identified. The toxicities seen in the repeated-dose studies are those expected to occur with continued exposure to exogenous adrenocortical steroids.

Carcinogenesis:

Methylprednisolone has not been formally evaluated in rodent carcinogenicity studies. Variable results have been obtained with other glucocorticoids tested for carcinogenicity in mice and rats. However, published data indicate that several related glucocorticoids including budesonide, prednisolone, and triamcinolone acetonide can increase the incidence of hepatocellular adenomas and carcinomas after oral administration in drinking water to male rats. These tumorigenic effects occurred at doses which were less than the typical clinical doses on a mg/m² basis.

Mutagenesis:

Methylprednisolone has not been formally evaluated for genotoxicity. However, methylprednisolone sulfonate, which is structurally similar to methylprednisolone, was not mutagenic with or without metabolic activation in *Salmonella typhimurium* at 250 to 2,000 μ g/plate, or in a mammalian cell gene mutation assay using Chinese hamster ovary cells at 2,000 to 10,000 μ g/mL. Methylprednisolone suleptanate did not induce unscheduled DNA synthesis in primary rat hepatocytes at 5 to 1,000 μ g/mL. Moreover, a review of published data indicates that prednisolone farnesylate (PNF), which is structurally similar to methylprednisolone, was not mutagenic with or without metabolic activation in *Salmonella typhimurium* and *Escherichia coli* strains at 312 to 5,000 μ g/plate. In a Chinese hamster fibroblast cell line, PNF produced a slight increase in the incidence of structural chromosomal aberrations with metabolic activation at the highest concentration tested 1,500 μ g/mL.

Reproductive toxicity:

Corticosteroids have been shown to reduce fertility when administered to rats. Male rats were administered corticosterone at doses of 0, 10, and 25 mg/kg/day by subcutaneous injection once daily for 6 weeks and mated with untreated females. The high dose was reduced to

20 mg/kg/day after Day 15. Decreased copulatory plugs were observed, which may have been secondary to decreased accessory organ weight. The numbers of implantations and live fetuses were reduced.

Corticosteroids have been shown to be teratogenic in many species when given in doses equivalent to the human dose. In animal reproduction studies, glucocorticoids, such as methylprednisolone have been shown to increase the incidence of malformations (cleft palate, skeletal malformations), embryo-fetal lethality (e.g., increase in resorptions), and intra-uterine growth retardation.

6. PHARMACEUTICAL PARTICULARS

6.1 List of Excipients

Dibasic sodium phosphate
Sodium hydroxide
Monobasic sodium phosphate monohydrate
Water for injection
Benzyl alcohol (in diluent)

6.2 Incompatibilities

The IV compatibility and stability of methylprednisolone sodium succinate solutions and with other drugs in intravenous admixtures is dependent on admixture pH, concentration, time, temperature, and the ability of methylprednisolone to solubilize itself. Thus to avoid compatibility and stability problems, whenever possible it is recommended that methylprednisolone sodium succinate be administered separately from other drugs and as either IV push, through an IV medication chamber, or as an IV “piggy-back” solution (see section 4.5 **Interaction with Other Medicinal Products and Other Forms of Interaction** for additional information).

6.3 Shelf-life

Please refer to outer carton for expiry date.

6.4 Special Precautions for Storage

Unreconstituted product: Store below 30°C.

Reconstituted solution (with bacteriostatic water for injection): Store below 25°C and use within 24 hours, or store between 2-8°C and use within 48 hours.

Admixture of reconstituted product: Store below 25°C and use within 12 hours, or store between 2-8°C and use within 48 hours.

6.5 Nature and Contents of Container

Each package contains a sterile powder for injection and a sterile solution.

SOLU-MEDROL Sterile powder 500 mg: 1 powder vial + 1 diluent vial
SOLU-MEDROL Sterile powder 1000 mg: 1 powder vial + 1 diluent vial

Some product strengths or pack sizes may not be available in your country.

6.6 Special Instructions for Use/Handling

Preparation of Solutions

To prepare solutions for intravenous infusion, first reconstitute methylprednisolone sodium succinate as directed. Therapy may be initiated by administering methylprednisolone sodium succinate intravenously over a period of at least five minutes (e.g., doses up to 250 mg) to at least 30 minutes (e.g., doses of 250 mg or more). Subsequent doses may be withdrawn and administered similarly. If desired, the medication may be administered in dilute solutions by admixing the reconstituted product with Dextrose 5% in Water, Normal Saline, Dextrose 5% in 0.45% or 0.9% Sodium Chloride; the resulting solutions are physically and chemically stable for 12 hours at 25°C and 48 hours at 2°C - 8°C.

Parenteral drug products should be inspected visually for particulate matter and discoloration prior to administration whenever solution and container permit.

7. MANUFACTURER

Pfizer Manufacturing Belgium NV,
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Belgium

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