

SUMMARY OF PRODUCT CHARACTERISTICS

1 NAME OF THE MEDICINAL PRODUCT

Doxorubicin 2 mg/ml concentrate for solution for infusion

2 QUALITATIVE AND QUANTITATIVE COMPOSITION

Each ml contains 2 mg doxorubicin hydrochloride.

Each 5 ml vial contains 10 mg of doxorubicin hydrochloride.

Each 25 ml vial contains 50 mg of doxorubicin hydrochloride.

Excipient(s) with known effect: sodium (3.5 mg/ml (0.15 mmol)).

For the full list of excipients, see section 6.1.

3 PHARMACEUTICAL FORM

Concentrate for solution for infusion.

The product is a clear, red solution, with a pH in the range of 2.5 – 3.5.

4 CLINICAL PARTICULARS

4.1 Therapeutic indications

Doxorubicin is indicated in the following neoplastic conditions; examples include:

- Small-cell lung cancer (SCLC)
- Breast cancer
- Recurrent ovarian carcinoma
- Intravesical prophylaxis of recurrences of superficial bladder carcinoma following transurethral resection (TUR)
- Systemic treatment of local advanced or metastasized bladder carcinoma
- Neoadjuvant and adjuvant therapy of osteosarcoma
- Advanced soft-tissue sarcoma in adults
- Hodgkin's disease
- Highly malignant Non-Hodgkin's lymphoma
- Induction and consolidation treatment in acute lymphatic leukaemia

- Acute myeloblastic leukaemia
- Advanced multiple myeloma
- Advanced or recurrent endometrial carcinoma
- Wilms' tumour (in stage II in highly malignant variants, in all advanced stages [III - IV])
- Advanced or relapsed papillary/follicular thyroid cancer
- Anaplastic thyroid cancer
- Advanced neuroblastoma

Doxorubicin is frequently used in combination chemotherapy regimens with other cytotoxic drugs.

4.2 Posology and method of administration

Treatment with Doxorubicin should be started by or after consultation with a doctor with extensive experience from cytostatic treatment.

Due to the risk of a lethal cardiomyopathy, the risks and benefits to the individual patient should be weighted before each application.

For intravenous use

Intravenous administration:

The dosage of doxorubicin depends on dosage regimen, general status and previous treatment of the patient.

In order to avoid cardiomyopathy, it is recommended that the cumulative total lifetime dose of doxorubicin (including related medicinal products such as daunorubicin) should not exceed 450-550 mg/m² body surface area. If patients with concomitant heart disease receive mediastinal and/or heart irradiation, prior treatment with alkylating agents or concomitant treatment with potentially cardiotoxic agents, and high-risk patients (with arterial hypertension since > 5 years, with prior coronary, valvular or myocardial heart damage, age over 70 years) a maximum total dose of 400 mg/m² body surface area should not be exceeded and the cardiac function of these patients should be monitored (see section 4.4)

The solution is given via the tubing of a freely running intravenous infusion of sodium chloride 0.9 % or dextrose 5 % into a large vein using a Butterfly needle, taking 2 to 3 minutes over the injection.

This technique minimises the risk of thrombosis or perivenous extravasation, which can lead to severe local cellulitis and necrosis.

Dosage is usually calculated on the basis of body surface area. On this basis, a dose of 60-75 mg/m² body surface area is recommended every three weeks when doxorubicin is used alone. If it is used in combination with other antitumour agents the dosage of doxorubicin should be reduced to 30-40 mg/m² every three weeks.

In patients, who cannot receive the full dose (e.g. in case of immunosuppression, old age), an alternative dosage is 15-20 mg/m² body surface per week.

Patients with prior radiotherapy

Patients who have received prior radiotherapy to the mediastinal/pericardial area should not receive doxorubicin greater than a total cumulative dose of 400 mg/m².

Elderly patients

Dosage may need to be reduced in the elderly.

Paediatric population

Dosage in children

Dosage for children should be reduced, since they have an increased risk for cardiac toxicity, especially late toxicity. Myelotoxicity should be anticipated, with nadirs at 10 to 14 days after start of treatment. The maximal cumulative dose in children is 400 mg/m².

Impaired hepatic function

If hepatic function is impaired, the dosage should be reduced according to the following table:

Serum Bilirubin Levels	BSP Retention	Recommended Dose
20-50 µmol/l	9-15 %	50 % normal dose
Over 50 µmol/l	Over 15 %	25 % normal dose

Renal impairment

In cases of renal insufficiency with a GFR less than 10 ml/min, 75 % of the calculated dose should be administered.

Obese patients

A reduced starting dose or prolonged dose interval might need to be considered in obese patients (see section 4.4).

For intravesical use

Intravesical administration:

Doxorubicin can be given by intravesical instillation for treatment of superficial cancer of the bladder and to prevent relapse after transurethral resection (T.U.R). The recommended dose for intravesical treatment of superficial cancer of the bladder is 30-50 mg in 25-50 ml of physiological saline per instillation. The optimal concentration is about 1 mg/ml. The solution should remain in the bladder for 1-2 hours. During this period the patient should be turned 90° every 15 minutes. To avoid undesired dilution with urine the patient should be informed not to drink anything for a period of 12 hours before the instillation (this should reduce the production of urine to about 50 ml/h). The instillation may be repeated with an interval of 1 week to 1 month, dependent on whether the treatment is therapeutic or prophylactic.

4.3 Contraindications

Hypersensitivity to the active substance or to any of the excipients listed in section 6.1.

- Contraindications for intravenous administration:

- persistent myelosuppression or severe stomatitis which appeared during previous cytotoxic treatment and/or radiation
- general infection
- severe impaired liver function
- severe arrhythmia, heart failure, previous cardiac infarct, acute inflammatory heart disease
- previous treatment with anthracyclines with maximum cumulative doses (see section 4.4)
- increased haemorrhagic tendency
- breast-feeding

Contraindications of intravesical administration:

invasive tumours that have penetrated the bladder (beyond T1)

urinary tract infections

inflammation of the bladder

problems with catheterization e.g. urethral stenosis

haematuria

breast-feeding

Dosage should not be repeated in the presence or development of bone marrow depression or buccal ulceration. The latter may be preceded by premonitory buccal burning sensations and repetition in the presence of this symptom is not advised.

4.4 Special warnings and precautions for use

Like all chemotherapy, therapy with Doxorubicin should be carried out only under the supervision of a qualified physician experienced in the use of cancer chemotherapeutic agents.

Appropriate management of therapy and complications is possible only when adequate diagnostic and treatment facilities are readily available.

Patients should recover from the acute toxicities of prior cytotoxic treatment (such as stomatitis, neutropenia, thrombocytopenia, and generalized infections) before beginning treatment with doxorubicin.

Before or during treatment with doxorubicin the following monitoring examinations are recommended (how often these examinations are done will depend on the general condition, the dose and the concomitant medication):

- radiographs of the lungs and chest and ECG
- regular monitoring of heart function (LVEF by e.g. ECG, UCG and MUGA scan)
- daily inspection of the oral cavity and pharynx for mucosal changes
- blood tests: haematocrit, platelets, differential white cell count, AST, ALT, LDH, bilirubin, uric acid.

Cardiac toxicity

Cardiotoxicity is a risk of anthracycline treatment that may be manifested by early (i.e. acute) or late (i.e. delayed) events.

Early (i.e. acute) events: Early cardiotoxicity of doxorubicin consists mainly of sinus tachycardia and/or ECG abnormalities such as non-specific ST-T wave changes. Tachyarrhythmias, including premature ventricular contractions and ventricular tachycardia, bradycardia, as well as atrioventricular and bundle-branch block have also been reported. These symptoms generally indicate acute transient toxicity. Flattening and widening of the QRS-complex beyond normal limits may indicate doxorubicin hydrochloride-induced cardiomyopathy. As a rule, in patients with a normal LVEF baseline value ($\geq 50\%$), a 10 % decrease of absolute value or dropping below the 50 % threshold indicates cardiac dysfunction and in such situation treatment with doxorubicin should be carefully considered.

Late (i.e. delayed) events: Delayed cardiotoxicity usually develops late in the course of therapy with doxorubicin or within 2 to 3 months after treatment termination, but later events, several months to years after completion of treatment, have also been reported. Delayed cardiomyopathy is manifested by reduced left ventricular ejection fraction (LVEF) and/or signs and symptoms of congestive heart failure (CHF) such as dyspnoea, pulmonary oedema, dependent oedema, cardiomegaly and hepatomegaly, oliguria, ascites, pleural effusion and gallop rhythm. Subacute effects such as pericarditis/myocarditis have also been reported. Life-threatening CHF is the most severe form of anthracycline-induced cardiomyopathy and represents the cumulative dose-limiting toxicity of the medicinal product.

Cardiac function should be assessed before patients undergo treatment with doxorubicin and must be monitored throughout therapy to minimize the risk of incurring severe cardiac impairment. The risk may be decreased through regular monitoring of LVEF during the course of treatment with prompt discontinuation of doxorubicin at the first sign of impaired function. The appropriate quantitative method for repeated assessment of cardiac function (evaluation of LVEF) includes multi-gated radionuclide angiography (MUGA) or echocardiography (ECHO). A baseline cardiac evaluation with an ECG and either a MUGA scan or an ECHO is recommended, especially in patients with risk factors for increased cardiotoxicity. Repeated MUGA or ECHO determinations of LVEF should be performed, particularly with higher, cumulative anthracycline doses. The technique used for assessment should be consistent throughout follow-up.

The probability of developing CHF, estimated around 1 % to 2 % at a cumulative dose of 300 mg/m² slowly increases up to the total cumulative dose of 450-550 mg/m². Thereafter, the risk of developing CHF increases steeply and it is recommended not to exceed a maximum cumulative dose of 550 mg/m². If the patient has other potential risk factors of cardiotoxicity (history of cardiovascular disease, previous therapy with other anthracyclines or anthracenediones, prior or concomitant radiotherapy to the mediastinal/ pericardial area, and concomitant use of medicinal products with the ability to suppress cardiac contractility, including cyclophosphamide and 5-fluoruracil), cardiotoxicity with doxorubicin may occur at lower cumulative doses and cardiac function should be carefully monitored. It is probable that the toxicity of doxorubicin and other anthracyclines or anthracenediones is additive.

Pre-treatment with digoxin (250 µg daily starting 7 days before doxorubicin) showed a protective effect against cardiotoxicity.

Myelosuppression

There is a high incidence of bone marrow depression, primarily of leucocytes, requiring careful haematological monitoring. With the recommended dosage schedule, leukopenia is usually transient, reaching its nadir at 10-14 days after treatment, with recovery usually occurring by the 21st day. White blood cell counts as low as 1,000/mm³ are to be expected during treatment with appropriate doses of doxorubicin. Red blood cell and platelet levels should also be monitored, since they may also be depressed. Clinical consequences of severe myelosuppression include fever, infections, sepsis/septicaemia, septic shock, haemorrhage, tissue hypoxia or death.

Myelosuppression is more common in patients who have had extensive radiotherapy, bone infiltration by tumour, impaired liver function (when appropriate dosage reduction has not been adopted) and simultaneous treatment with other myelosuppressive agents. Haematological toxicity may require dose reduction or suspension or delay of doxorubicin therapy. Persistent severe myelosuppression may result in superinfection or haemorrhage. Careful haematological monitoring is required due to the myelosuppressive effects.

The occurrence of secondary acute myeloid leukaemia with or without a pre-leukaemic phase has been reported rarely in patients concurrently treated with doxorubicin in association with DNA damaging antineoplastic agents. Such cases could have a short (1-3 year) latency period.

Radiotherapy

Special caution is mandatory for patients who have had radiotherapy previously, are having radiotherapy concurrently or are planning to have radiotherapy. These patients are at special risk of local reactions in the radiation field (recall phenomenon) if doxorubicin is used. Severe, sometimes fatal, hepatotoxicity (liver damage) has been reported in this connection. Prior radiation to the mediastinum increases the cardiotoxicity of doxorubicin. The cumulative dose of 400 mg/m² must not be exceeded especially in this case.

Immunosuppression

Doxorubicin is a powerful but temporary immunosuppressant agent. Appropriate measures should be taken to prevent secondary infection.

Vaccines

This medicinal product is generally not recommended in combination with live, attenuated vaccines.

Contact to persons recently vaccinated against polio should be avoided.

Enhanced toxicity

It has been reported that doxorubicin may enhance the severity of the toxicity of other anticancer therapies, such as cyclophosphamide induced haemorrhagic cystitis, mucositis induced by radiotherapy, hepatotoxicity of 6-mercaptopurine and the toxicity of streptozocin or methotrexate (see section 4.5).

Hepatic impairment

Toxicity to recommended doses of doxorubicin is enhanced by hepatic impairment. It is recommended that an evaluation of hepatic function be carried out prior to individual dosing, using conventional clinical laboratory tests such as AST, ALT, alkaline phosphatase, bilirubin and BSP. If required, dosage schedules should be reduced accordingly (see section 4.2).

Carcinogenesis, mutagenesis and impairment of fertility

Doxorubicin was genotoxic and mutagenic in vitro and in vivo tests.

In women, doxorubicin may cause amenorrhoea. Ovulation and menstruation appear to return after termination of therapy, although premature menopause can occur.

Doxorubicin is mutagenic and can induce chromosomal damage in human spermatozoa. Oligospermia or azospermia may be permanent; however, sperm counts have been reported to return to normospermic levels in some instances. This may occur several years after the end of therapy.

Administration site conditions

Local erythematous streaking along the vein as well as facial flushing may be indicative of too rapid administration.

On intravenous administration of doxorubicin, a stinging or burning sensation signifies extravasation. Even if blood return from aspiration of the infusion needle is good, the injection or infusion should be immediately terminated and restarted in another vein. In the event of inadvertent extravasation, ice packs should be applied to the injection site. Local injection of dexamethasone or hydrocortisone may be used to minimise local tissue necrosis. Hydrocortisone cream 1 % may also be applied locally. Doxorubicin must not be given intrathecally or intramuscularly or by long-term infusion. Direct intravenous infusion is not advised due to the tissue damage that may occur if the infusion infiltrates the tissues. If a central vein catheter is used then infusion of doxorubicin in sodium chloride 0.9 % injection is advised.

Others

Precaution is also required during simultaneous or previous radiotherapy of the mediastinal/pericardial area or after treatment with other cardiotoxic substances.

Doxorubicin may induce hyperuricaemia as a consequence of the extensive purine catabolism that accompanies rapid lysis of neoplastic cells induced by the medicinal product (tumour-lysis syndrome) (see section 4.8). Blood uric acid levels, potassium, calcium phosphate and creatinine should be evaluated after initial treatment. Hydration, urine alkalization, and prophylaxis with allopurinol to prevent hyperuricaemia may minimize potential complications of tumour lysis syndrome.

Intravesical administration

Intravesical administration of doxorubicin may cause symptoms of chemical cystitis (i.e. dysuria, urinary frequency, nocturia, stranguria, haematuria, necrosis of the bladder wall). Special attention is needed in case of catheter problems (i.e. urethral obstruction caused by invasion of intravesical tumour). Intravesical administration is contraindicated for tumours that have penetrated the bladder (beyond T1).

The intravesical route of administration should not be attempted in patients with invasive tumours that have penetrated the bladder wall, urinary tract infections, inflammatory conditions of the bladder.

The patient should be informed that the urine might be reddish, particularly in the first specimen after administration, but that this is no cause for alarm.

5 ml vial: This medicine contains 17.7 mg sodium (< 1 mmol) per 5 ml vial of concentrate, that is to say essentially 'sodium-free'.

25 ml vial: This medicine contains 88.5 mg sodium (main component of cooking/table salt) in each 25 ml vial of concentrate. This is equivalent to 4.4% of the recommended maximum daily dietary intake of sodium for an adult.

4.5 Interaction with other medicinal products and other forms of interaction

Concurrent administration of other antineoplastic agents, e.g.: anthracyclines (daunorubicin, epirubicin, idarubicin), cisplatin, cyclophosphamide, cyclosporin, cytarabine, dacarbazine, dactinomycin, fluorouracil, mitomycin C and taxanes can potentiate the risk of doxorubicin-induced congestive heart failure. The disposition of doxorubicin was found to be significantly altered when it was administered immediately after a short intravenous infusion of paclitaxel. The co-administration of paclitaxel causes a decreased clearance of doxorubicin and more neutropenic and stomatitis episodes have been observed.

Increased cardiotoxicity has also been reported after simultaneous intake of cardioactive medicinal products, e.g., calcium channel blockers and verapamil (with an increase of doxorubicin peak levels, terminal-half life and volume of distribution). The bioavailability of digoxin decreases during doxorubicin therapy. Careful monitoring of the heart function is required in all such concomitant therapeutic regimens.

The use of trastuzumab in combination with anthracyclines (such as doxorubicin) is associated with a high cardiotoxic risk. Trastuzumab and anthracyclines should not be used in combination for the time being, except in well controlled clinical studies where the cardiac function is monitored. When anthracyclines are used after the end of a therapy with trastuzumab, an elevated risk of cardiotoxicity may result. If possible, there should be a sufficiently long interval (up to 22 weeks) between the end of a therapy with trastuzumab and the beginning of the anthracycline therapy. Careful monitoring of the cardiac function is imperative.

Doxorubicin undergoes metabolism via Cytochrome P450 (CYP450) and is a substrate for the Pgp transporter. Concomitant administration of inhibitors of CYP450 and/or Pgp might lead to increased plasma concentrations of doxorubicin and thereby increased toxicity. Conversely, concomitant administration of inducers of CYP450, such as rifampicin and barbiturates, might decrease plasma concentrations of doxorubicin and reduce efficacy.

Ciclosporin, an inhibitor of CYP3A4 and Pgp, increased the AUC of doxorubicin and doxorubicinol by 55 % and 350 %, respectively. The combination might require dose adjustment. Cimetidine has also been shown to reduce the plasma clearance and increase the AUC of doxorubicin.

If doxorubicin therapy is followed by administration of cyclophosphamide, an increased rate of haemorrhagic cystitis has been reported.

The absorption of antiepileptic medicinal products (e.g. carbamazepine, phenytoin, valproate) is decreased after concomitant use of doxorubicin.

As doxorubicin is rapidly metabolised and predominantly eliminated by the biliary system, the concomitant administration of known hepatotoxic chemotherapeutic agents (e.g. mercaptopurine, methotrexate, streptozocin) could potentially increase the toxicity of doxorubicin as a result of reduced hepatic clearance of the medicinal products. Dosing of doxorubicin must be modified if concomitant therapy with hepatotoxic medicinal products is mandatory.

Disturbed haemotopoiesis has been observed after co-administration of substances influencing the bone-marrow function (e.g. amidopyrine derivatives, antiretroviral medicinal products, chloramphenicol, phenytoin, sulphonamides). Increased neutropenia and thrombocytopenia have been reported after simultaneous use of progesterone. Marked nephrotoxicity of amphotericin B can occur during doxorubicin therapy. Elevated serum doxorubicin concentrations were reported after the concomitant administration of doxorubicin and ritonavir.

The toxic effects of a doxorubicin therapy may be increased in a combination with other cytostatics (e.g. cytarabine, cisplatin, cyclophosphamide). Necroses of the large intestine with massive haemorrhage and severe infections in connection with combination therapies with cytarabine have been reported.

Clozapine may increase the risk and severity of the hematologic toxicity of Doxorubicin.

Doxorubicin is a potent, radiosensitizing agent ("radiosensitizer"), and recall phenomena induced by it may be life-threatening. Any preceding, concomitant or subsequent radiation therapy may increase the cardiotoxicity or hepatotoxicity of doxorubicin.

Doxorubicin may cause exacerbations of hemorrhagic cystitis caused by previous cyclophosphamide therapy.

Doxorubicin may reduce oral bioavailability of digoxin.

Doxorubicin therapy may lead to increased serum uric acid; therefore dose adjustment of uric acid lowering agents may be necessary.

Live vaccines must not be used during doxorubicin therapy due to the risk of generalised disease, which may be lethal. The risk is increased in patients who are

immunodepressed due to the underlying disease. During treatment with Doxorubicin patients should also avoid contact with recently polio vaccinated persons.

Co-administration of heparin and doxorubicin can lead to an increase in the rate of doxorubicin clearance. Furthermore, precipitates may form and lead to a loss of efficacy of both medicinal products (see section 6.2).

4.6 Fertility, pregnancy and lactation

Pregnancy

Doxorubicin should not be given during pregnancy. In general cytostatics should only be administered during pregnancy on strict indication, and the benefit to the mother weighed against possible hazards to the foetus. In animal studies, doxorubicin has shown embryo-, fetotoxic- and teratogenic effects (see section 5.3). Women should not become pregnant during and up to 6 months after treatment. Men treated with doxorubicin are advised not to father a child during and up to 6 months after treatment.

Men and women should use effective contraception during and up to 6 months after treatment (see section 4.4).

Breast-feeding

Doxorubicin has been reported to be excreted in human breast milk. A risk to the suckling child cannot be excluded. Since the use of doxorubicin during breast-feeding is contraindicated, breast-feeding should be discontinued during treatment with doxorubicin (see section 4.3).

Fertility

In women, doxorubicin may cause infertility during the period of administration of the medicinal product. Men being treated with doxorubicin are advised to seek advice on cryo-conservation (or cryopreservation) of sperm prior to treatment because of the possibility of reversible infertility due to therapy with doxorubicin.

4.7 Effects on ability to drive and use machines

Due to the frequent occurrence of nausea and vomiting, driving cars and operation of machinery should be discouraged.

4.8 Undesirable effects

Treatment with doxorubicin often causes undesirable effects, and some of these effects are serious enough to entail careful monitoring of the patient. The frequency

and kind of undesirable effects are influenced by the speed of administration and the dosage. Bone-marrow suppression is an acute dose limiting adverse effect, but is mostly transient. Clinical consequences of doxorubicin bone marrow/haematological toxicity may be fever, infections, sepsis/septicaemia, haemorrhages, tissue hypoxia or death. Nausea and vomiting as well as alopecia are seen in almost all patients.

Within each system organ class, the adverse events have been ranked under the headings of frequency, most frequent reactions first. For the evaluation of adverse effects the following frequency specification will be used:

Very common ($\geq 1/10$)

Common ($\geq 1/100$ to $< 1/10$)

Uncommon ($\geq 1/1,000$ to $< 1/100$)

Rare ($\geq 1/10,000$ to $< 1/1,000$)

Very rare ($< 1/10,000$)

Not known (cannot be estimated from the available data)

Infections and infestations	Common:	Sepsis, septicaemia
Neoplasms benign, malignant and unspecified (incl cysts and polyps)	Rare:	Secondary acute myeloid leukaemia when given in combination with anti-neoplastic medicinal products which damage the DNA. (see section 4.4); tumour lysis syndrome
Blood and lymphatic system disorders	Common:	Bone-marrow depression, leucopenia (see section 4.4)
	Not known:	Thrombocytopenia, anaemia (see section 4.4)
Immune system disorders	Rare:	Anaphylactic reactions
Endocrine disorders	Not known:	Hot flushes
Eye disorders	Rare:	Conjunctivitis, lacrimation
Cardiac disorders	Common:	Cardiotoxicity, i.e. cardiomyopathy (2 %; e.g. decrease of LVEF, dyspnoea); ECG changes (e.g. sinus tachycardia, congestive heart failure; tachyarrhythmia, ventricular tachycardia, bradycardia, bundle branch block)
	Not known:	Arrhythmia; severe cardiac failure may occur suddenly, without premonitory ECG changes
Vascular disorders	Uncommon:	Phlebosclerosis
	Not known:	Thrombophlebitis, thromboembolism
Respiratory, thoracic and Mediastinal disorders	Not known:	Bronchospasm, radiation pneumonitis
Gastrointestinal disorders	Common:	Nausea; vomiting; anorexia; diarrhoea; Mucositis most commonly develops 5 to 10 days after treatment, and typically begins as a burning sensation in the mouth and pharynx. It may involve the vagina, rectum and oesophagus, and progress to ulceration with risk of secondary infection and usually subsides in 10 days. Mucositis

		may be severe in patients who have had previous irradiation to the mucosae.
	Uncommon:	Gastrointestinal haemorrhage, abdominal pain; ulceration and necrosis of the colon; stomatitis; oesophagitis
Hepatobiliary disorders	Not known:	Hepatotoxicity, transient increase of liver enzymes (see section 4.4)
Skin and subcutaneous tissue disorders	Common:	Alopecia
	Uncommon	Recall of skin reaction due to prior radiotherapy
	Rare:	Urticaria; tissue necrosis; local erythematous reactions along the vein which was used for the injection, hyperpigmentation of nail beds, onycholysis, dermal increases (primarily in children)
	Not known:	Tissue hypoxia, palmar–plantar erythrodysaesthesia syndrome
Renal and urinary disorders	Common:	Haemorrhagic cystitis; Local reactions (chemical cystitis) might occur at intravesical treatment (i.e. dysuria, urinary frequency, nocturia, stranguria, haematuria, necrosis of the bladder wall)
	Not known:	Renal damage, acute renal failure; hyperuricaemia (see section 4.4)
Reproductive system and breast disorders	Not known:	Doxorubicin may cause infertility during the time of administration of the medicinal product. Although ovulation and menstruation appear to return after termination of therapy, there is only scarce information about the restoration of male fertility. Amenorrhoea, oligospermia, azoospermia (see section 4.4)
General disorders and administration site conditions	Uncommon:	Dehydration
	Rare:	Anaphylactic reactions, shivering, fever, dizziness
	Not known:	A stinging or burning sensation at the administration site (see section 4.4); malaise/weakness; red colour of the urine
Surgical and medical procedures	Not known:	Extravasation can lead to severe cellulitis, vesication and local tissue necrosis which

	may require surgical measures (including skin grafts)
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Reporting of suspected adverse reactions

Reporting suspected adverse reactions after authorisation of the medicinal product is important. It allows continued monitoring of the benefit/risk balance of the medicinal product. Healthcare professionals are asked to report any suspected adverse reactions via the yellow card scheme at: www.mhra.gov.uk/yellowcard or search for MHRA Yellow Card in the Google Play or Apple App Store.

4.9 Overdose

The symptoms of overdose are likely to be an extension of doxorubicin's pharmacological action. Single doses of 250 mg and 500 mg of doxorubicin have proven to be fatal. Such doses

may cause acute myocardial degeneration within 24 hours, and severe myelosuppression, the greatest effects of which are seen between 10 and 15 days after administration. Delayed cardiac failure may occur up to six months after the overdose. Treatment should aim to support the patient during this period. Particular attention should be given to prevention and treatment of possible severe haemorrhage or infections secondary to severe, persistent bone marrow depression. Blood transfusion and reverse barrier nursing may be considered.

Hemoperfusion immediately after the overdose proved to be a rescue measure, too. Delayed cardiac failure may occur up to six month after the overdose. Patients should be observed carefully and, should signs of cardiac failure arise, be treated along conventional lines.

5 PHARMACOLOGICAL PROPERTIES

5.1 Pharmacodynamic properties

Pharmacotherapeutic group: Cytotoxic agents (anthracyclines and related substances)
ATC code: L01DB01

Doxorubicin is an anthracycline antibiotic. It exerts its antineoplastic effect via cytotoxic

mechanisms of action, especially intercalation into DNA, inhibition of the enzyme topoisomerase II, and formation of reactive oxygen species (ROS). All of these have a deleterious effect on DNA synthesis: Intercalation of the doxorubicin molecule leads to an inhibition of RNA and DNA polymerases by way of disturbances in base recognition and sequence specificity. The inhibition of topoisomerase II produces single and double strand breaks of the DNA helix. Scission of DNA also originates from the chemical reaction with highly reactive oxygen species like the hydroxyl radical OH_h. Mutagenesis and chromosomal aberrations are the consequences.

The specificity of doxorubicin toxicity appears to be related primarily to proliferative activity of normal tissue. Thus, bone marrow, gastro-intestinal tract and gonads are the main normal tissues damaged.

An important cause of treatment failure with doxorubicin and other anthracyclines is the development of resistance. In an attempt to overcome cellular resistance to doxorubicin, the use of calcium antagonists such as verapamil has been considered since the primary target is the cell membrane. Verapamil inhibits the slow channel of calcium transport and can enhance cellular uptake of doxorubicin. A combination of doxorubicin and verapamil is associated with severe toxic effects in animal experiments.

5.2 Pharmacokinetic properties

Following intravenous injection, doxorubicin is rapidly cleared from the blood, and distributed into tissues including lungs, liver, heart, spleen, lymph nodes, bone marrow and kidneys. Relatively low but persistent levels are found in tumour tissue.

Doxorubicin undergoes rapid metabolism in the liver. Doxorubicinol is the most common metabolite, although a substantial fraction of patients forms doxorubicin-7-deoxyglycone and doxorubicinol-7-deoxyglycone. About 40 to 50 % of a dose is excreted in bile within 7 days, of which about half is as unchanged active substance. Only about 5 % of a dose is excreted in urine within 5 days. Doxorubicinol, the major (active) metabolite, is excreted in both bile and urine. It does not cross the blood-brain barrier, but does cross the placenta and is distributed into breast milk. The elimination of doxorubicin from the blood is triphasic with mean half-lives of 12 minutes, 3.3 hours and about 30 hours.

The volume of distribution V_d is 25 l; the degree of protein binding is 60–70 %. There is substantial interpatient variation in biotransformation. Clearance is apparently not dose-related, but it is higher in men than in women.

Impairment of liver function results in slower excretion, and consequently, increased retention and accumulation in plasma and tissues. Dose reduction is generally advised although there is no clear relationship between liver function tests, doxorubicin clearance and clinical toxicity. Since doxorubicin and metabolites are excreted in the urine only to a minor degree, there are no clear indications that the pharmacokinetics or toxicity of doxorubicin are altered in patients with impaired renal function.

Although renal excretion is a minor elimination pathway for doxorubicin, severe renal impairment might affect total elimination and require dose reduction.

In a study in obese patients (> 130 % of ideal bodyweight) the doxorubicin clearance was reduced and the half-life increased compared with a normal-weight control group. Dose adjustments might be necessary in the obese.

5.3 Preclinical safety data

Animal studies from literature show that doxorubicin affects the fertility, is embryo- and foetotoxic and teratogenic. Other data shows that doxorubicin is mutagenic.

6 PHARMACEUTICAL PARTICULARS

6.1 List of excipients

Sodium chloride
Hydrochloric acid (for pH adjustment)
Water for injections

6.2 Incompatibilities

Doxorubicin must not be mixed with heparin, as this will result in precipitation. Until detailed compatibility information about miscibility is available, Doxorubicin should not be mixed with other medicinal products than those mentioned under section 6.6.

Incompatibilities with the following products have been reported:
Aminophyllin, cephalotin, dexamethasone, fluorouracil, hydrocortisone.

Prolonged contact with any solution of an alkaline pH should be avoided, as it will result in hydrolysis of the medicinal product.

6.3 Shelf life

Unopened vials: 2 years.

Opened vials: The product should be used immediately after opening the vial.

Prepared infusion solutions:

Chemical and physical in-use stability has been demonstrated in 0.9% sodium chloride injection and 5% dextrose injection for up to 7 days at 2 – 8°C and 25°C when prepared in glass containers protected from light.

From a microbiological point of view, the product should be used immediately. If not used immediately, in-use storage times and conditions prior to use are the

responsibility of the user and would normally not be longer than 24 hours at 2°C to 8°C, unless dilution has taken place in controlled and validated aseptic condition.

6.4 Special precautions for storage

Store in a refrigerator (2°C – 8°C).

Keep the vial in the outer carton in order to protect from light.

For storage conditions after dilution of the medicinal product, see section 6.3.

6.5 Nature and contents of container

For 5 ml, concentrate for solution for infusion is filled in 5 ml Type I amber tubular glass vial closed with chlorobutyl rubber stopper with aluminium flip-off cap.

For 25 ml, concentrate for solution for infusion is filled in 25 ml Type I amber tubular glass vial closed with chlorobutyl rubber stopper with aluminium flip-off cap.

6.6 Special precautions for disposal

For single use only.

Doxorubicin is a potent cytotoxic agent which should only be prescribed, prepared and administered by professionals who have been trained in the safe use of the preparation. The following guidelines should be followed when handling, preparing and disposing of doxorubicin.

Preparation

1. Personnel should be trained in good technique for handling.
2. Pregnant staff should be excluded from working with this drug.
3. Personnel handling doxorubicin should wear protective clothing: goggles, gowns, disposable gloves and masks.
4. All items used for administration or cleaning, including gloves, should be placed in high risk waste disposal bags for high temperature (700°C) incineration.
5. All cleaning materials should be disposed of as indicated previously.
6. Always wash hands after removing gloves.

Contamination

1. In case of contact with skin or mucous membrane, thoroughly wash the affected area with soap and water or sodium bicarbonate solution. However, do not graze the skin by using a scrubbing brush. A bland cream may be used to treat transient stinging of skin.

2. In case of contact with eye(s), hold back the eyelid(s) and flush the affected eyes with copious amounts of water for at least 15 minutes or normal sodium chloride 9 mg/ml (0.9%) solution for injection. Then seek medical evaluation by a physician or eye specialist.
3. In the event of spillage or leakage treat with 1% sodium hypochlorite solution or most simply with phosphate buffer (pH>8) until solution is destained. Use a cloth/sponge kept in the designate area. Rinse twice with water. Put all cloths into a plastic bag and seal for incineration.

Disposal

Single use only. Any unused medicinal product or waste materials that have been used for dilution and administration must be destroyed according to hospital standard procedures applicable to cytotoxic agents with due regard to current laws related to the disposal of hazardous waste.

Medicines should not be disposed of via wastewater or household waste. These measures will help to protect the environment.

7 MARKETING AUTHORISATION HOLDER

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