



GleolanTM
(aminolevulinic acid HCl)

Product Monograph¹

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SUMMARY

Gleolan (aminolevulinic acid hydrochloride) is an optical imaging agent indicated in patients with glioma (suspected World Health Organization Grades III or IV on preoperative imaging) as an adjunct for the visualization of malignant tissue during surgery.

During glioma surgery, Gleolan is used with a standard surgical operating microscope adapted with a blue light emitting source (power density 40-80 mW/cm²) and filters for excitation of light at wavelength 375 to 440 nm, and observation at wavelengths of 620 to 710 nm. This allows tumor tissue to be visualized as red-violet fluorescence. Tissue lacking sufficient PpIX concentrations appear blue.

The safety of Gleolan is supported by data from 5 open label clinical studies, which included 527 patients with glioma who received ALA. Adverse reactions that occurred in > 1% of patients in the week following surgery were pyrexia, hypertension, nausea, and vomiting.

Adverse reactions occurring in the first 6 weeks after surgery in < 1% of patients were: chills, photosensitivity reaction, solar dermatitis, hypotension, abnormal liver function test, and diarrhea. One patient experienced respiratory failure due to drug overdose. For further safety information, please refer to the Important Safety Information (ISI) section below on pages 5 & 6 and the Package Insert is enclosed at the end of the document.

The efficacy was evaluated in 3 clinical studies in patients who had a preoperative MRI compatible with high grade glioma (WHO Grades III or IV) and were undergoing surgical resection. Study 3 was a randomized, multicenter study in 415 patients with a preoperative diagnosis of high-grade glioma by MRI. Patients were randomized in 1:1 ratio to ALA fluorescence arm or to white light control arm. In patients with confirmed high-grade glioma randomized to the ALA fluorescence arm, presence of fluorescence at a biopsy level was compared to tumor status using histopathology as the reference standard (Refer to Table 1 in Clinical Studies Section).

The extent of resection among patients with confirmed high-grade glioma in the ALA fluorescence arm was compared to that among patient in the control arm, with the "completeness" of resection being determined by a central blinded read of early post-surgical MRI. Percentage of patients who had "completeness" of resection was 64% in the ALA arm and 38% in the control arm, with the difference of 26% [95% CI: (16%, 36%)].

SUMMARY

Gleolan is for oral use only. The recommended reconstituted oral dose of Gleolan is 20 mg/kg body weight and is administered 3 hours (range 2-4 hours) prior to anesthesia. Exogenous administration of Gleolan leads to production of a unique fluorescent metabolite (PpIX) which allows for real time visualization of tumor tissue during the surgical procedure. Refer to Figure 1 for an example.

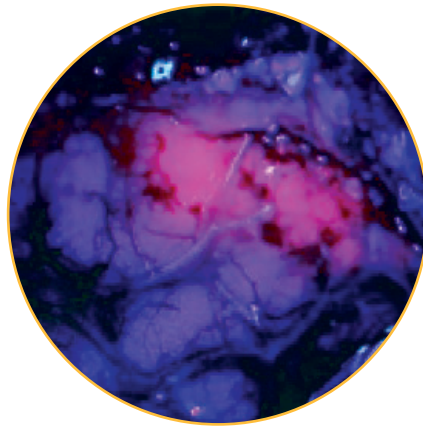


FIGURE 1: Fluorescing Tumor Tissue
Permission granted by Dr. Walter Stummer

Gleolan is supplied as 1,500 mg of lyophilized ALA HCl powder (equivalent to 1,170 mg ALA), for oral solution in a 50-mL clear, colorless, glass vial with a rubber stopper and an aluminum crimp seal.

It is to be stored at 25 °C (77 °F); excursions are permitted to 15-30 °C (59-86 °F).

Gleolan should only be used at hospitals confirmed to have the appropriate microscope and filters and by neurosurgeons who have completed a training program provided by the distributor NXDC.

SUMMARY

Important Safety Information

Contraindications

Do not use Gleolan in patients with:

- hypersensitivity to the active substance
- with acute or chronic types of porphyria

Warnings and Precautions

Due to the risk of phototoxic reactions, do not administer phototoxic drugs for 24 hours during the perioperative period. Reduce exposure to sunlight or room lights for 48 hours after administration of Gleolan.

Errors may occur with the use of Gleolan for intraoperative visualization of malignant glioma, including false negatives and false positives. Non-fluorescing tissue in the surgical field does not rule out the presence of tumor in patients with glioma. Fluorescence may be seen in areas of inflammation or metastases from other tumor types.

Hypersensitivity reactions, including serious hypersensitivity reactions have occurred; these reactions include anaphylactic shock, swelling, and urticaria. Always have cardiopulmonary resuscitation personnel and equipment readily available and monitor all patients for hypersensitivity reactions.

Adverse Reactions

Adverse reactions occurring in >1% of patients in the week following surgery were pyrexia, hypertension, nausea, and vomiting.

Nervous system disorders occurred in 29% of patients within the first week after surgery and events occurring in >1% of patients included: aphasia (8%), hemiparesis (7.8%), hemianopia (3.2%), headache (2.7%), seizure (1.9%), hemiplegia (1.9%), monoparesis (1.3%) and hypoesthesia (1.1%). Brain edema occurred in <1% of patients in the first 6 weeks after surgery. In a randomized clinical trial, the numbers of serious neurologic adverse events in the post operative period were higher in patients randomized to ALA fluorescence arm compared to the control arm. This imbalance was notable for the terms aphasia, ataxia, convulsion and hemianopsia and is likely related to the higher amount of brain resection performed in the ALA arm. At longer follow up periods, the numbers between the two arms appeared similar.

Worsening of ≥ 2 Common Toxicity Criteria grades in alanine aminotransferase and gamma-glutamyl transferase occurred in 15.8% and 11.6% of patients, respectively, within the first week after surgery. Absolute levels ranged from 2 times to greater than 10 times the upper limit of normal for each parameter. At 6 weeks these measurements remained elevated in 2.9% and 7.5% of patients, respectively. There were no cases of liver failure.

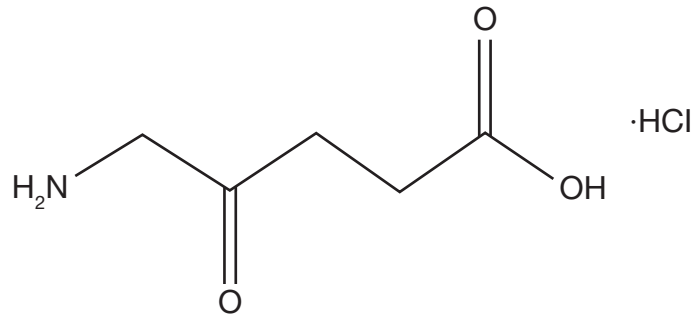
Drug-Drug Interactions

See information under Warning and Precautions regarding phototoxic reactions.

DESCRIPTION

- › **Class:** Optical Imaging Agent
- › **Route of Administration:** Oral
- › **National Drug Code (NDC):** 71469-0231-01
- › **Chemical Properties:**

Gleolan (aminolevulinic acid hydrochloride) is an optical imaging agent provided as a lyophilized single dosing unit that requires reconstitution prior to oral use. The 50-mL, clear vial contains 1,500 mg of lyophilized ALA HCl powder (equivalent to 1,170 mg ALA). After reconstitution, the product has a concentration of 30 mg ALA HCl per mL (equivalent to 23.4 mg ALA per mL). The chemical name is 5-amino-4-oxo-pentanoic acid hydrochloride. The chemical formula for ALA HCl is $C_5H_{10}ClNO_3$. Its molecular weight is 167.59 g/mol with the following structural formula:



› Mechanism of Action:

Aminolevulinic acid hydrochloride (ALA) occurs endogenously as a metabolite that is formed in the mitochondria from succinyl-CoA and glycine. Exogenous administration of ALA (non-fluorescent) leads to accumulation of the ALA metabolite PpIX in tumor cells. The reason for the accumulation of PpIX (fluorescent) in neoplastic brain tissue is not known.

CLINICAL PHARMACOLOGY

› Pharmacodynamics:

The effect of the timing of the Gleolan dosing on fluorescence intensity in brain tissue is unknown. The relationship between systemic ALA plasma concentrations at the time of visualization and fluorescence intensity in brain is also unknown. The dose of 20 mg/kg provided stronger ALA-induced fluorescence in glioma tissue by both visual and spectrophotometric assessment compared to lower doses tested.

Cardiac Electrophysiology:

Administration of the approved recommended dose of Gleolan did not prolong the QT interval to any clinically relevant extent.

› Pharmacokinetics

In 12 healthy subjects, the mean half-life of ALA following the recommended dose of Gleolan solution was 0.9 +/- 1.2 hours (mean + std dev) with a range of 0.8 to 1.3 hours. Maximum concentrations of the PpIX metabolite (T_{max} for PpIX) occurred with a median of 4 hours and a range of 1.2 to 7.8 hours. The elimination half-life of PpIX was 3.6 +/- 1.8 hours (mean +/- std dev) with a range of 1.2 to 7.8 hours.

Absorption:

In 12 healthy subjects, the absolute bioavailability of ALA following the recommended dose of Gleolan solution was 100.0% +/- 1.1 with a range of 78.5% to 131.2%. Maximum ALA plasma concentrations were reached with a median of 0.8 hour (range 0.5 – 1.0 hour).

Distribution:

In in vitro experiments using ALA concentrations up to approximately 25% of the maximal concentration that occurs in plasma following the recommended dose of Gleolan solution, the mean protein binding of ALA was 12%.

Metabolism:

Exogenous ALA is metabolized to PpIX, but the fraction of administered ALA that is metabolized to PpIX is unknown. The average plasma AUC of PpIX is less than 6% of that of ALA.

Excretion:

In 12 healthy subjects, excretion of parent ALA in urine in the 12 hours following administration of the recommended dose of Gleolan solution was 34 +/- 8% (mean +/- std dev) with a range of 27% to 57%.

CLINICAL PHARMACOLOGY

› Use in Specific Populations

Pregnancy:

There are no available human data on Gleolan in pregnant women to inform a drug associated risk of adverse developmental outcomes. In animal reproduction studies, no adverse developmental effects were observed with oral ALA HCl administration to pregnant rabbits during organogenesis at doses 3 times the maximum recommended human oral dose (*see Data*).

The estimated background risk of major birth defects and miscarriage for the indicated populations are unknown. All pregnancies have a background risk of birth defect, loss, or other adverse outcomes. In the U.S. general population, the estimated background risk of major birth defects and miscarriage in clinically recognized pregnancies is 2-4% and 15-20%, respectively.

Lactation:

There are no data on the presence of ALA HCl in either human or animal milk, the effects on the breastfed infant, or the effects on milk production. The developmental and health benefits of breastfeeding should be considered along with the mother's clinical need for Gleolan and any potential adverse effects on the breastfed infant from Gleolan or from the underlying maternal condition.

Clinical Considerations:

To decrease exposure to Gleolan to the breastfed infant, advise a lactating woman to pump and discard breast milk after the administration of Gleolan for 24 hours (i.e., 5 to 6 half-lives).

Pediatric Use:

The safety and effectiveness of Gleolan in pediatric patients have not been established.

Geriatric Use:

Of 527 subjects in clinical studies of Gleolan, 182 were 65 to < 75 years of age and 7 were ≥ 75 years of age. No overall differences in safety or effectiveness were observed between these subjects and younger subjects, and other reported clinical experience has not identified differences in responses between the elderly and younger patients, but greater sensitivity of some older individuals cannot be ruled out. No dose adjustment is required in elderly patients.

INDICATIONS and USAGE/CONTRAINDICATIONS

Patients with Renal Impairment:

Because approximately one third of the ALA dose is excreted in urine as parent drug, ALA clearance may be reduced in patients with renal impairment; it is not known if dose adjustment is needed.

Patients with Hepatic Impairment:

The contribution of the liver to the elimination of ALA following Gleolan dosing is unknown. ALA clearance may be reduced in patients with hepatic impairment; it is not known if dose adjustment is needed.

Indications & Usage:

Gleolan is an optical imaging agent indicated in patients with glioma (suspected World Health Organization Grades III or IV on preoperative imaging) as an adjunct for the visualization of malignant tissue during surgery.

Contraindications:

- Hypersensitivity to the active substance or porphyrins.
- Acute or chronic types of porphyria, due to potential ineffectiveness of the drug in these patients.

CLINICAL STUDIES

The efficacy of 20 mg / kg ALA HCl was evaluated in 3 clinical studies (Study 1-3) involving patients, ages 18 to 75 years old, who had a preoperative MRI compatible with high-grade glioma (WHO Grade III or IV) and were undergoing surgical resection.

Study 1 was an open-label study of 33 patients with newly diagnosed high-grade glioma and Study 2 was an open-label study of 36 patients with recurrent high-grade glioma. In Studies 1 and 2, after initial debulking was carried out under white light, biopsies were obtained under fluorescent light from fluorescent and nonfluorescent sites. Presence of fluorescence (positive/negative) was compared to tumor status (true/false) using histopathology as the reference standard. True positives and false positives among fluorescent biopsies and true negatives and false negatives among nonfluorescent biopsies are provided in Table 1.

Study 3 was a randomized, multicenter study in 415 patients with a preoperative diagnosis of high-grade glioma by MRI. Patients were randomized in 1:1 ratio to ALA fluorescence arm or to white light control arm. Biopsies were obtained from tumor-core, tumor-margin and regions just distant to the tumor margins. In 349 patients high grade glioma was confirmed by a blinded central read and histopathology. The remaining patients were diagnosed with metastatic disease, abscess, low-grade glioma or other conditions.

In patients with confirmed high-grade glioma randomized to the ALA fluorescence arm, presence of fluorescence at a biopsy level was compared to tumor status using histopathology as the reference standard (Table 1). In 4 patients with low-grade glioma (WHO Grade I or II) who received ALA, 9 out of 10 biopsies were false negative.

The extent of resection among patients with confirmed high-grade glioma in the ALA fluorescence arm was compared to that among patient in the control arm, with the “completeness” of resection being determined by a central blinded read of early post-surgical MRI. Percentage of patients who had “completeness” of resection was 64% in the ALA arm and 38% in the control arm, with the difference of 26% [95% CI: (16%, 36%)].

Table 1. Presence of Fluorescence Compared to Histopathology (biopsy level)

	Study 1 (N=297)*	Study 2 (N=370)*	Study 3 (N=479)*
Number of Fluorescent Biopsies	185	354	319
True Positive	178	342	312
False Positive	7	12	7
Number of Nonfluorescent Biopsies	112	16	160
True Negative	27	3	30
False Negative	85	13	130

* N is Number of total (fluorescent and non-fluorescent) biopsies

WARNINGS

Risk of Phototoxic Reaction:

Due to the risk of phototoxic reactions, do not administer phototoxic drugs for 24 hours during the perioperative period. Reduce exposure to sunlight or room lights for 48 hours after oral administration of Gleolan.

Risk of Misinterpretation:

Errors may occur with the use of Gleolan for intraoperative visualization of malignant glioma, including false negatives and false positives. Non-fluorescing tissue in the surgical field does not rule out the presence of tumor in patients with glioma. Fluorescence may be seen in areas of inflammation or metastases from other tumor types.

Hypersensitivity Reactions:

Hypersensitivity reactions, including serious hypersensitivity reactions have occurred; these reactions include anaphylactic shock, swelling, and urticaria. Always have cardiopulmonary resuscitation personnel and equipment readily available and monitor all patients for hypersensitivity reactions.

PRECAUTIONS

› Drug-Drug Interactions:

Phototoxic Drugs

Patients exposed to a photosensitizing agent may experience a phototoxic skin reaction (severe sunburn). Due to the risk of possible phototoxic reactions, avoid administering phototoxic drugs such as St. John's wort, griseofulvin, thiazide diuretics, sulfonylureas, phenothiazines, sulphonamides, quinolones and tetracyclines, and topical preparations containing ALA for 24 hours before and after administration of Gleolan.

ADVERSE REACTIONS

Clinical Trial Experience:

Because clinical trials are conducted under widely varying conditions, adverse reaction rates observed in the clinical trials of a drug cannot be directly compared to rates in the clinical trials of another drug and may not reflect the rates observed in practice.

The safety of Gleolan is supported by data from 5 open label clinical studies, which included 527 patients with glioma who received ALA. Adverse reactions that occurred in > 1% of patients in the week following surgery were pyrexia, hypertension, nausea, and vomiting.

Adverse reactions occurring in the first 6 weeks after surgery in < 1% of patients were: chills, photosensitivity reaction, solar dermatitis, hypotension, abnormal liver function test, and diarrhea. One patient experienced respiratory failure due to drug overdose.

Neurologic Events:

Nervous system disorders occurred in 29% of patients within the first week after surgery. Events occurring in > 1% of patients included aphasia (8%), hemiparesis (7.8%), hemianopsia (3.2%), headache (2.7%), seizure (1.9%), hemiplegia (1.9%), monoparesis (1.3%) and hypoesthesia (1.1%). Brain edema occurred in < 1 % of patients in the first 6 weeks after surgery. In a randomized clinical trial (Study 3), the numbers of serious neurologic adverse events in the post-operative period were higher in patients randomized to ALA fluorescence arm compared to the control arm. This imbalance was notable for the terms aphasia, ataxia, convulsion and hemianopsia, and is likely related to the higher amount of brain resection performed in the ALA arm. At longer follow up periods, the numbers between the two arms appeared similar.

Elevated Liver Enzymes:

Worsening of ≥ 2 Common Toxicity Criteria (CTC) grades in alanine aminotransferase (ALT) and gamma-glutamyl transferase (GGT) occurred in (15.8% and 11.6%, respectively) within the first week after surgery. Absolute levels ranged from 2 times to greater than 10 times the upper limit of normal (ULN) for each parameter. At 6 weeks, ALT remained elevated in 2.9% of patients (range 2 to greater than 5 X ULN), and GGT was elevated in 7.5% of patients (range 2 to greater than 10 X ULN). No cases of liver failure occurred.

Post Marketing Experience:

The following adverse reactions are among those that have been identified during post- approval use of Gleolan outside of the United States. Because these reactions are reported voluntarily from a population of uncertain size, it is not always possible to reliably estimate their frequency or establish a causal relationship to drug exposure.

Immune Disorders: anaphylactic shock, angioedema, drug eruption, urticaria, erythema.

Metabolism and nutrition disorders: metabolic acidosis.

OVERDOSE

Overdosage has been associated with respiratory insufficiency and erythema. In the event of overdose, supportive measures should be provided as necessary, including protection from strong light sources.

DOSAGE and ADMINISTRATION

Recommended Dose:

- For oral use only
- The recommended oral dose of reconstituted ALA HCl solution is 20 mg / kg body weight. More than 1 vial may be required.

Reconstitution of Gleolan:

Gleolan powder must be reconstituted prior to administration by a healthcare provider according to the following instructions:

- Determine the total number of vials needed to achieve the intended dose for the patient according to the equation below (rounded up to the nearest whole vial):

$$\# \text{ of vials} = \frac{\text{Patient Body Weight (kg)}}{75 \text{ kg/vial}}$$

- *Completely* remove the white cap and aluminum crimp seal from each vial.
- Remove and retain the rubber stopper from the vial.
- Using an appropriate volumetric measuring device (e.g., flask, graduated cylinder, dosing syringe), measure 50 mL of drinking water and add to each vial containing 1,500 mg of Gleolan.
- Gently swirl the vial to completely dissolve the ALA HCl.
- The resulting reconstituted solution (30 mg of ALA HCl per mL) is clear and colorless to slightly yellowish.
- If required, replace the stopper and store reconstituted solution for up to 24 hours at room temperature prior to administration.

DOSAGE and ADMINISTRATION

Gleolan Administration:

Gleolan is for **ORAL USE ONLY**. The reconstituted Gleolan solution is administered according to the following steps:

- Calculate the administration volume, in mL, to achieve the intended dose according to the following equation:

$$\text{Administration Volume (mL)} = \frac{\text{Patient Body Weight (kg)} \times 20 \text{ mg/kg}}{30 \text{ mg/mL}}$$

- Transfer the entire contents of the prepared vial(s) into an appropriate dosing container (e.g. oral medicine bottle); ensure the entire contents of the vials are transferred.
- After transfer, discard the empty vial(s).
- Using a disposable volumetric syringe, remove the administration volume of the reconstituted Gleolan solution from the dosing container and transfer to a separate oral dosing container.
- Discard unneeded volume of Gleolan solution.

Administer orally 3 hours (range 2 to 4 hours) prior to induction of anesthesia.

SUPPLIED, STORAGE and HANDLING

Supplied:

Gleolan is supplied as 1,500 mg of lyophilized ALA HCl powder (equivalent to 1,170 mg ALA), for oral solution in a 50-mL clear, colorless, glass vial with a rubber stopper and an aluminum crimp seal (*Figure 2*).



FIGURE 2: Gleolan 50-mL Single Dose Vial

Storage and Handling:

Store at 25 °C (77 °F); excursions permitted to 15–30 °C (59–86 °F).

REFERENCES

1. Gleolan™ [aminolevulinic acid hydrochloride], Prescribing Information. Lexington, KY; NX Development Corporation; 2018

HIGHLIGHTS OF PRESCRIBING INFORMATION

These highlights do not include all the information needed to use GLEOLAN safely and effectively. See full prescribing information for GLEOLAN.

GLEOLAN™ [aminolevulinic acid hydrochloride (ALA HCl)] for oral solution
Initial U.S. Approval: [1999]

INDICATIONS AND USAGE

Gleolan is an optical imaging agent indicated in patients with glioma (suspected World Health Organization Grades III or IV on preoperative imaging) as an adjunct for the visualization of malignant tissue during surgery.

DOSAGE AND ADMINISTRATION

- For oral use only
- Recommended reconstituted oral dose of Gleolan is 20 mg/kg. (2.1)
- Administer Gleolan to patient orally 3 hours (range 2 to 4 hours) before anesthesia. (2.1)
- See Full Prescribing Information for reconstitution information. (2.2)
- Use appropriate visualization techniques with appropriate surgical microscopes and light source filters. (2.3)

DOSAGE FORMS AND STRENGTHS

For oral solution: 1,500 mg ALA HCl lyophilized powder, equivalent to 1,170 mg ALA per vial. The reconstituted ALA HCl solution contains 30 mg per mL and is clear and colorless to slightly yellowish in color.

CONTRAINDICATIONS

- Hypersensitivity to ALA or porphyrins. (4, 5.3, 6.2)
- Acute or chronic types of porphyria. (4)

WARNINGS AND PRECAUTIONS

- Phototoxic reactions: Do not administer phototoxic drugs (St. John's wort, griseofulvin, thiazide diuretics, sulfonyleureas, phenothiazines, sulphonamides, quinolones and tetracyclines), and topical preparations containing ALA for 24 hours during the perioperative period. Reduce exposure to sunlight or room lights for 48 hours after oral administration of Gleolan. (5.1, 7)
- Risk of misinterpretation: Non-fluorescing tissue in the surgical field does not rule out the presence of tumor. (5.2, 14)

ADVERSE REACTIONS

- Adverse reactions occurring in >1% of patients in the week following surgery were pyrexia, hypertension, nausea, and vomiting.
- Adverse reactions occurring in < 1% of patients in the first 6 weeks after surgery were: chills, photosensitivity reaction, solar dermatitis, hypotension, abnormal liver function test, and diarrhea.
- Neurologic events related to the surgical procedure occurred in 29% of patients and included: aphasia, hemiparesis, hemianopia, headache, seizure, hemiplegia, monoparesis, hypoesthesia, and brain edema.
- Elevated liver enzymes occurred in clinical studies. There were no cases of liver failure. (6.1)

To report SUSPECTED ADVERSE REACTIONS, contact NXDC toll-free at (844-517-5252 and info@nxdevcorp.com) or FDA at 1-800-FDA-1088 or www.fda.gov/medwatch.

See 17 for PATIENT COUNSELING INFORMATION

Revised: 04/2018

FULL PRESCRIBING INFORMATION: CONTENTS*

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*Sections or subsections omitted from the full prescribing information are not listed.

FULL PRESCRIBING INFORMATION

1 INDICATIONS AND USAGE

Gleolan is indicated in patients with glioma [suspected World Health Organization (WHO) Grades III or IV on preoperative imaging] as an adjunct for the visualization of malignant tissue during surgery.

2 DOSAGE AND ADMINISTRATION

2.1 Recommended Dose

- For oral use only
- The recommended oral dose of reconstituted ALA HCl solution is 20 mg / kg body weight. More than 1 vial may be required.

2.2 Reconstitution of Gleolan

Gleolan powder must be reconstituted prior to administration by a healthcare provider according to the following instructions:

- Determine the total number of vials needed to achieve the intended dose for the patient according to the equation below (rounded up to the nearest whole vial):

$$\# \text{ of vials} = \frac{\text{Patient Body Weight (kg)}}{75 \text{ kg/vial}}$$

- Completely remove the white cap and aluminum crimp seal from each vial..
- Remove and retain the rubber stopper from the vial.
- Using an appropriate volumetric measuring device (e.g., flask, graduated cylinder, dosing syringe), measure 50 mL of drinking water and add to each vial containing 1,500 mg of Gleolan.
- Gently swirl the vial to completely dissolve the ALA HCl.
- The resulting reconstituted solution (30 mg of ALA HCl per mL) is clear and colorless to slightly yellowish.
- If required, replace the stopper and store reconstituted solution for up to 24 hours at room temperature prior to administration.

2.3 Gleolan Administration

Gleolan is for ORAL USE ONLY. The reconstituted Gleolan solution is administered according to the following steps:

- Calculate the administration volume, in mL, to achieve the intended dose according to the following equation:

$$\text{Administration Volume (mL)} = \frac{\text{Patient Body Weight (kg)} * 20\text{mg/kg}}{30 \text{ mg/mL}}$$

- Transfer the entire contents of the prepared vial(s) into an appropriate dosing container (e.g., oral medicine bottle); ensure the entire contents of the vials are transferred.
- After transfer, discard the empty vial(s).
- Using a disposable volumetric syringe, remove the administration volume of reconstituted Gleolan solution from the dosing container and transfer to a separate oral dosing container.
- Discard unneeded volume of Gleolan solution.
- Administer orally 3 hours (range 2 to 4 hours) prior to induction of anesthesia.

2.4 Imaging Instructions

- Gleolan must be used with a standard surgical operating microscope adapted with a blue light emitting light source (power density 40-80 mW/cm²) and ancillary excitation and emission filters to visualize fluorescence excitation in the wavelength of 375 to 440 nm and for observation from 620 to 710 nm. Filters transmit porphyrin fluorescence as red-violet, as well as a fraction of backscattered blue excitation light necessary for distinguishing nonfluorescing tissue.
- Gleolan should only be used by neurosurgeons who have completed a training program on use of fluorescence in surgery. Training is provided by the distributor.

3 DOSAGE FORMS AND STRENGTHS

For oral solution: 1,500 mg ALA HCl lyophilized powder, equivalent to 1,170 mg ALA, in a 50 mL single-dose clear, colorless, glass vial with rubber stopper. After reconstitution with 50 mL drinking water, the solution contains 30 mg per mL of ALA HCl (equivalent to 23.4 mg per mL of ALA) and is clear and colorless to slightly yellowish in color.

4 CONTRAINDICATIONS

- Hypersensitivity to the active substance or porphyrins.
- Acute or chronic types of porphyria, due to potential ineffectiveness of the drug in these patients.

5 WARNINGS AND PRECAUTIONS

5.1 Risk of Phototoxic Reaction

Due to the risk of phototoxic reactions, do not administer phototoxic drugs for 24 hours during the perioperative period [see *Drug Interactions (7)*]. Reduce exposure to sunlight or room lights for 48 hours after administration of Gleolan.

5.2 Risk of Misinterpretation

Errors may occur with the use of Gleolan for intraoperative visualization of malignant glioma, including false negatives and false positives. Non-fluorescing tissue in the surgical field does not rule out the presence of tumor in patients with glioma [see *Clinical Studies (14)*]. Fluorescence may be seen in areas of inflammation or metastases from other tumor types.

5.3 Hypersensitivity Reactions

Hypersensitivity reactions, including serious hypersensitivity reactions have occurred; these reactions include anaphylactic shock, swelling, and urticaria [see *Adverse Reactions (6.2)*]. Always have cardiopulmonary resuscitation personnel and equipment readily available and monitor all patients for hypersensitivity reactions.

6 ADVERSE REACTIONS

6.1 Clinical Trial Experience

Because clinical trials are conducted under widely varying conditions, adverse reaction rates observed in the clinical trials of a drug cannot be directly compared to rates in the clinical trials of another drug and may not reflect the rates observed in practice.

The safety of Gleolan is supported by data from 5 open label clinical studies, which included 527 patients with glioma who received ALA. Adverse reactions that occurred in > 1% of patients in the week following surgery were pyrexia, hypertension, nausea, and vomiting. Adverse reactions occurring in the first 6 weeks after surgery in < 1% of patients were: chills, photosensitivity reaction, solar dermatitis, hypotension, abnormal liver function test, and diarrhea. One patient experienced respiratory failure due to drug overdose [see *Overdosage (10)*].

Neurologic Events

Nervous system disorders occurred in 29% of patients within the first week after surgery. Events occurring in > 1% of patients included aphasia (8%), hemiparesis (7.8%), hemianopsia (3.2%), headache (2.7%), seizure (1.9%), hemiplegia (1.9%), monoparesis (1.3%) and hypoesthesia (1.1%). Brain edema occurred in < 1% of patients in the first 6 weeks after surgery. In a randomized clinical trial (Study 3), the numbers of serious neurologic adverse events in the post operative period were higher in patients randomized to ALA fluorescence arm compared to the control arm. This imbalance was notable for the terms aphasia, ataxia, convulsion and hemianopsia, and is likely related to the higher amount of brain resection performed in the ALA arm. At longer follow up periods, the numbers between the two arms appeared similar [see *Clinical Trials (14)*].

Elevated Liver Enzymes

Worsening of ≥ 2 Common Toxicity Criteria (CTC) grades in alanine aminotransferase (ALT) and gamma-glutamyl transferase (GGT) occurred in (15.8% and 11.6%, respectively) within the first week after surgery. Absolute levels ranged from 2 times to greater than 10 times the upper limit of normal (ULN) for each parameter. At 6 weeks, ALT remained elevated in 2.9% of patients (range 2 to greater than 5 X ULN), and GGT was elevated in 7.5% of patients (range 2 to greater than 10 X ULN). No cases of liver failure occurred.

6.2 Post Marketing Experience

The following adverse reactions are among those that have been identified during post-approval use of Gleolan outside of the United States. Because these reactions are reported voluntarily from a population of uncertain size, it is not always possible to reliably estimate their frequency or establish a causal relationship to drug exposure.

Immune Disorders: anaphylactic shock, angioedema, drug eruption, urticaria, erythema.

Metabolism and Nutrition Disorders: metabolic acidosis.

7 DRUG INTERACTIONS

Drug-Drug Interactions

Phototoxic Drugs

Patients exposed to a photosensitizing agent may experience a phototoxic skin reaction (severe sunburn). Due to the risk of possible phototoxic reactions, avoid administering phototoxic drugs such as St. John's wort, griseofulvin, thiazide diuretics, sulfonyleureas, phenothiazines, sulphonamides, quinolones and tetracyclines, and topical preparations containing ALA for 24 hours before and after administration of Gleolan.

8 USE IN SPECIFIC POPULATIONS

8.1 Pregnancy

Risk Summary

There are no available human data on Gleolan in pregnant women to inform a drug associated risk of adverse developmental outcomes. In animal reproduction studies, no adverse developmental effects were observed with oral ALA HCl administration to pregnant rabbits during organogenesis at doses 3 times the maximum recommended human oral dose.

The estimated background risk of major birth defects and miscarriage for the indicated populations are unknown. All pregnancies have a background risk of birth defect, loss, or other adverse outcomes. In the U.S. general population, the estimated background risk of major birth defects and miscarriage in clinically recognized pregnancies is 2-4% and 15-20%, respectively.

Animal data

ALA HCl was administered to rabbits at oral doses of 15, 50 and 150 mg/kg/day [approximately 0.1, 0.6, and 3 times the maximum human recommended dose (MHRD), respectively based on AUC comparisons] from gestation days 6-18. The no-observed-adverse-effect level (NOAEL) for maternal toxicity was 50 mg/kg/day and the NOAEL for embryo-fetal developmental toxicity was 150 mg/kg/day.

8.2 Lactation

Risk summary

There are no data on the presence of ALA HCl in either human or animal milk, the effects on the breastfed infant, or the effects on milk production. The developmental and health benefits of breastfeeding should be considered along with the mother's clinical need for Gleolan and any potential adverse effects on the breastfed infant from Gleolan or from the underlying maternal condition.

Clinical Considerations

To decrease exposure to Gleolan to the breastfed infant, advise a lactating woman to pump and discard breast milk after the administration of Gleolan for 24 hours (i.e., 5 to 6 half-lives).

8.4 Pediatric Use

The safety and effectiveness of Gleolan in pediatric patients have not been established.

8.5 Geriatric Use

Of 527 subjects in clinical studies of Gleolan, 182 were 65 to < 75 years of age and 7 were ≥ 75 years of age. No overall differences in safety or effectiveness were observed between these subjects and younger subjects, and other reported clinical experience has not identified differences in responses between the elderly and younger patients, but greater sensitivity of some older individuals cannot be ruled out. No dose adjustment is required in elderly patients.

8.6 Patients with Renal Impairment

Because approximately one third of the ALA dose is excreted in urine as parent drug, ALA clearance may be reduced in patients with renal impairment; it is not known if dose adjustment is needed [see *Clinical Pharmacology* (12.3)].

8.7 Patients with Hepatic Impairment

The contribution of the liver to the elimination of ALA following Gleolan dosing is unknown. ALA clearance may be reduced in patients with hepatic impairment; it is not known if dose adjustment is needed [see *Clinical Pharmacology* (12.3)].

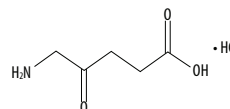
10 OVERDOSAGE

Overdosage has been associated with respiratory insufficiency and erythema. In the event of overdose, supportive measures should be provided as necessary, including protection from strong light sources.

11 DESCRIPTION

11.1 Chemical Properties

Gleolan (aminolevulinic acid hydrochloride) is an optical imaging agent for oral solution. The 50-mL, clear vial contains 1,500 mg of lyophilized ALA HCl powder (equivalent to 1,170 mg ALA). After reconstitution, the product has a concentration of 30 mg ALA HCl per mL (equivalent to 23.4 mg ALA per mL). The chemical name is 5-amino-4-oxo-pentanoic acid hydrochloride. The chemical formula for ALA HCl is $C_5H_{10}ClNO_3$. Its molecular weight is 167.59 g/mol with the following structural formula:



12 CLINICAL PHARMACOLOGY

12.1 Mechanism of Action

ALA occurs endogenously as a metabolite that is formed in the mitochondria from succinyl-CoA and glycine. Exogenous administration of ALA leads to accumulation of the ALA metabolite PpIX in tumor cells. The reason for the accumulation of PpIX in neoplastic brain tissue is not known.

During glioma surgery, Gleolan is used with an operating microscope adapted with a blue emitting light source (power density 40-80 mW/cm²) and filters for excitation light of wavelength 375 to 440 nm, and observation at wavelengths of 620 to 710 nm. This allows tumor tissue to be visualized as red fluorescence. Tissue lacking sufficient PpIX concentrations appears blue.

12.2 Pharmacodynamics

The effect of the timing of the Gleolan dosing on fluorescence intensity in brain tissue is unknown. The relationship between systemic ALA plasma concentrations at the time of visualization and fluorescence intensity in brain is also unknown. The dose of 20 mg / kg provided stronger ALA-induced fluorescence in glioma tissue by both visual and spectrophotometric assessment compared to lower doses tested.

Cardiac Electrophysiology

Administration of the approved recommended dose of Gleolan did not prolong the QT interval to any clinically relevant extent.

12.3 Pharmacokinetics

In 12 healthy subjects, the mean half-life of ALA following the recommended dose of Gleolan solution was 0.9 ± 1.2 hours (mean \pm std dev) with a range of 0.8 to 1.3 hours. Maximum concentrations of the PpIX metabolite (T_{max} for PpIX) occurred with a median of 4 hours and a range of 1.2 to 7.8 hours. The elimination half-life of PpIX was 3.6 ± 1.8 hours (mean \pm std dev) with a range of 1.2 to 7.8 hours.

Absorption

In 12 healthy subjects, the absolute bioavailability of ALA following the recommended dose of Gleolan solution was 100.0% ± 1.1 with a range of 78.5% to 131.2%. Maximum ALA plasma concentrations were reached with a median of 0.8 hour (range 0.5 – 1.0 hour).

Distribution

In *in vitro* experiments using ALA concentrations up to approximately 25% of the maximal concentration that occurs in plasma following the recommended dose of Gleolan solution, the mean protein binding of ALA was 12%.

Elimination

Metabolism

Exogenous ALA is metabolized to PpIX, but the fraction of administered ALA that is metabolized to PpIX is unknown. The average plasma AUC of PpIX is less than 6% of that of ALA.

Excretion

In 12 healthy subjects, excretion of parent ALA in urine in the 12 hours following administration of the recommended dose of Gleolan solution was 34 ± 8% (mean ± std dev) with a range of 27% to 57%.

Specific Populations

The effect of renal or hepatic impairment on the pharmacokinetics of ALA following Gleolan administration is unknown.

Drug Interaction Studies

In vitro studies suggest that phenytoin and other anti-convulsants may decrease cellular PpIX accumulation following Gleolan dosing.

ALA is not an inhibitor of CYP1A2, 2B6, 2C8, 2C9, 2C19, 2D6, or 3A.

13 NONCLINICAL TOXICOLOGY

13.1 Carcinogenesis, Mutagenesis, Impairment of Fertility

Carcinogenesis

No carcinogenicity studies have been conducted with Gleolan.

Mutagenesis

ALA HCl was not mutagenic in the Ames assay, HPRT-V79 mammalian cell mutagenicity test, the peripheral human lymphocyte chromosomal aberration assay and the *in vivo* mouse micronucleus test when studies were performed in the dark or under subdued lighting.

Impairment of Fertility

No fertility studies have been conducted with Gleolan.

14 CLINICAL STUDIES

The efficacy of 20 mg / kg ALA HCl was evaluated in 3 clinical studies (Study 1-3) involving patients, ages 18 to 75 years old, who had a preoperative MRI compatible with high-grade glioma (WHO Grade III or IV) and were undergoing surgical resection.

Study 1 was an open-label study of 33 patients with newly diagnosed high-grade glioma and Study 2 was an open-label study of 36 patients with recurrent high-grade glioma. In Studies 1 and 2, after initial debulking was carried out under white light, biopsies were obtained under fluorescent light from fluorescent and nonfluorescent sites. Presence of fluorescence (positive/negative) was compared to tumor status (true/false) using histopathology as the reference standard. True positives and false positives among fluorescent biopsies and true negatives and false negatives among nonfluorescent biopsies are provided in Table 1.

Study 3 was a randomized, multicenter study in 415 patients with a preoperative diagnosis of high-grade glioma by MRI. Patients were randomized in 1:1 ratio to ALA fluorescence arm or to white light control arm. Biopsies were obtained from tumor-core, tumor-margin and regions just distant to the tumor margins. In 349 patients high grade glioma was confirmed by a blinded central read and histopathology. The remaining patients were diagnosed with metastatic disease, abscess, low-grade glioma or other conditions.

In patients with confirmed high-grade glioma randomized to the ALA fluorescence arm, presence of fluorescence at a biopsy level was compared to tumor status using histopathology as the reference standard (Table 1). In 4 patients with low-grade glioma (WHO Grade I or II) who received ALA, 9 out of 10 biopsies were false negative.

The extent of resection among patients with confirmed high-grade glioma in the ALA fluorescence arm was compared to that among patient in the control arm, with the "completeness" of resection being determined by a central blinded read of early post-surgical MRI. Percentage of patients who had "completeness" of resection was 64% in the ALA arm and 38% in the control arm, with the difference of 26% [95% CI: (16%, 36%)].

Table 1. Presence of Fluorescence Compared to Histopathology (biopsy level)

	Study 1 (N=297)*	Study 2 (N=370)*	Study 3 (N=479)*
Number of Fluorescent Biopsies	185	354	319
True Positive	178	342	312
False Positive	7	12	7
Number of Nonfluorescent Biopsies	112	16	160
True Negative	27	3	30
False Negative	85	13	130

* N is Number of total (fluorescent and non-fluorescent) biopsies

16 HOW SUPPLIED/STORAGE AND HANDLING

16.1 How Supplied

Gleolan (NDC 71469-231-01) is supplied as 1,500 mg of lyophilized ALA HCl powder (equivalent to 1,170 mg ALA), for oral solution in a 50-mL clear, colorless, glass vial with a rubber stopper and an aluminum crimp seal.

16.2 Storage and Handling

Store at 25 °C (77 °F); excursions permitted to 15-30 °C (59-86 °F).

17 PATIENT COUNSELING INFORMATION

Advise patients that they may experience elevated liver enzymes (ALT and GGT) within the first week after surgery. This elevation may persist after 6 weeks.

Advise patients to reduce exposure to sunlight or room lights for 48 hours after administration of Gleolan due to risk of phototoxic reactions.

Distributed by NX Development Corp.
870 Corporate Drive, Suite 403
Lexington, KY 40503

Manufactured by LYOCONTRACT GmbH
Pulverwiese 1
Ilseburg, 38871, Germany

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