9602901-2
IPOS

REPLACED SHEETS SG
☑ Description : paged ....1.... to paged ....15....
☑ Claim(s) : paged ....16.... to paged ....20....
☑ Drawing(s) : paged ....15.... to paged ....5/5....
☑ Abstract : paged ....21.... to paged ....1....
DATE OF RECEIPT .....

TITLE OF THE INVENTION

THE USE OF HYALURONIC ACID TO REPAIR ISCHEMIA REPERFUSION DAMAGE

FIELD OF INVENTION

This invention relates to repair through reperfusion of ischemia damage to tissue particularly internal organs and most particularly to the liver, heart, and kidneys and formulations for use to repair through reperfusion such ischemia damage and methods of treating such conditions.

BACKGROUND OF THE INVENTION

United States Patent 4,801,619 relates to hyaluronic acid administered intra-articularly having a molecular weight of about 3 X 10^6 dalton more, which is prone to decrease the proteoglycan content of synovial fluid to almost normal levels. According to this patent, this indicates a positive effect on the proteoglycan metabolism of a joint. According to the Patent this is applicable both to inflammatory conditions and to degeneration caused by treatment with symptomatics, such as corticosteroid preparations. It is thus clear that a sufficiently high molecular weight of the hyaluronic acid is alleged to counteract side effects that might be caused by corticosteroids or other symptomatics producing similar effects. When corticosteroids are applied, the amount of hyaluronic acid in the synovial cavity will according to the Patent increase substantially and according to the inventors their hyaluronic acid preparations have a very positive effect on such clinical symptoms as pain, swelling and lameness.

The patent states that the objectives of the invention are attained by intra-articular administration of an effective amount of hyaluronic acid with a mean molecular weight exceeding 3 X 10^6 dalton, preferably exceeding 4 X 10^6 dalton; usually the molecular weight will not exceed 7 X 10^6 dalton. The dosage of hyaluronic acid administered is stated to be preferably within the range of 5mg-80mg. The amount of solution given at each administration is generally less than 60 ml, e.g. less that 20 ml, of an aqueous solution of the acid or its salt. It is convenient to administer the acid dissolved in water (<2% w/w, buffered to physiological pH), for instance in the form of a water-

This Sheet Has Been Replaced

soluble sodium salt. The exact amount will depend on the particular joint to be treated.

The Merck Index specifies that hyaluronic acid has a molecular weight within the range pf 50,000 to 8 X 10^6 depending on source, methods of preparation and methods of determination. The Merck Publication teaches hyaluronic acid as a surgical aid (ophthalmological).

United States Patent 4,808,576 purports to teach that hyaluronic acid, an agent well known to reduce the sequelae of trauma in mammalian joint tissue when applied directly to the traumatized tissue, will be carried to such traumatized tissue by the mammal's natural processes if applied at a site remote from the traumatized tissue. Thus hyaluronic acid in any therapeutically acceptable form can, according to the Patent, be administered by the typical remote routes including intravenous, intramuscular, subcutaneous and topical.

This, the patent alleges, makes the utilization of hyaluronic acid much more convenient and attractive. For instance the treatment of arthritis in horse or human joints with hyaluronic acid according to the patent no longer requires more difficult intra articular injections.

United States Patent 4,725,585 relates to a method of enhancing or regulating the host defence of a mammal, said method comprising administering to a mammal a therapeutically effective amount of hyaluronic acid.

At column 1 lines 43 - 46, the patent provides that the invention was based on the unexpected discovery that administration of hyaluronic acid to mammals results in a considerable increase in the defence.

We have now discovered that hyaluronic acid and its salts and other forms are useful in repairing ischemia reperfusion damage in tissue particularly internal organs and most particularly the liver.

This Sheet Has Been Replaced

SUMMARY OF THE INVENTION

According to one aspect of the invention, a formulation for administration to a mammal is provided comprising an amount of hyaluronic acid and or salts thereof and/or homologues, analogues, derivatives, complexes, esters, fragments and sub units of hyaluronic acid effective to prevent or repair ischemia reperfusion damage in tissue particularly internal organs for example the liver, together with a pharmaceutical carrier.

The hyaluronic acid in a carrier may be administered intravenously, by infusion or any other suitable method and may be administered up to about 7gm per 70 kg person per day. While reduced amounts of hyaluronic acid may be delivered in the carrier it is preferable that the least amount of hyaluronic acid be in the range of about 300mg/70kg person per day.

According to another aspect of the invention, a method of repairing ischemia reperfusion damage in tissue, particularly internal organs, and more particularly the liver, is provided comprising administering to the mammal a therapeutically effective amount of hyaluronic acid and or salts thereof and/or homologues, analogues, derivatives, complexes, esters, fragments and sub units of hyaluronic acid in a suitable carrier. Because hyaluronic acid targets the damaged tissue and facilitates its own penetration through the tissue at the site to be treated through the cell membranes into the individual cells to be treated, it rapidly arrives at the site after introduction, for example, by intravenous methods and repairs the ischemia reperfusion damage in the tissue, for example the liver, or prevents or minimizes such damage (as for example in transplants such as the liver, heart, lungs, and kidneys).

The formulation can be administered among other methods, intravenously, intra-arterially, intraperitoneally, intrapleurally, transdermally, on the skin, or by direct injection (for example into the liver).

This Sheet Has Been Replaced



One form of hyaluronic acid and/or salts thereof (for example sodium salt) and homologues, analogues, derivatives, complexes, esters, fragments and sub units of hyaluronic acid, preferably hyaluronic acid and salts and thereof suitable for use with Applicant's invention is a fraction suppled by Hyal Pharmaceuticals Limited. One such fraction is a 15 ml vial of Sodium hyaluronate 20mg/ml (300mg/vial - Lot 2F3). The sodium hyaluronate fraction is a 2% solution with a mean average molecular weight of about 225,000. The fraction also contains water q.s. which is triple distilled and sterile in accordance with the U.S.P. for injection formulations. The vials of hyaluronic acid and/or salts thereof may be carried in Type 1 borosilicate g vial closed by a butyl stopper which does not react with the contents of the vial.

The fraction of hyaluronic acid and/or salts thereof (for example sodium salt) and homologues, analogues, derivatives, complexes, esters, fragments and sub units of hyaluronic acid, preferably hyaluronic acid and salts and thereof may comprise hyaluronic acid and/or salts thereof having the following characteristics:

a purified, substantially pyrogen-free fraction of hyaluronic acid obtained from a natural source having at least one characteristic selected from the group consisting of the following:

(i) a molecular weight within the range of 150,000 -700,000;

(ii) less than about 1.25% sulphated mucopolysaccharides on a total weight basis;

(iii) less than about 0.6% protein on a total weight basis;

(iv) less than about 150 ppm iron on a total weight basis;

(v) less than about 15 ppm lead on a total weight basis;

(vi) less than 0.0025% glucosamine;

(vii) less than 0.025% glucuronic acid;

(viii) less than 0.025% N-acetylglucosamine;

(ix) less than 0.0025% amino acids;

This Sheet Has Been Replaced

(x) a UV extinction coefficient at 257 nm of less than about 0.275;

(xi) a UV extinction coefficient at 280nm of less than about 0.25; and

(xii) a pH within the range of 7.3 - 7.9.

Preferably the hyaluronic acid is mixed with water and the fraction of hyaluronic acid fraction has a mean average molecular weight within the range of 150,000 - 225,000. More preferably the fraction of hyaluronic acid comprises at least one characteristic selected from the group consisting of the following characteristics:

(i) less than about 1% sulphated mucopolysaccharides on a total weight basis;

(ii) less than about 0.4% protein on a total weight basis;

(iii) less than about 100 ppm iron on a total weight basis;

(iv) less than about 10 ppm lead on a total weight basis;

(v) less than 0.00166% glucosamine;

(vi) less than 0.0166% glucuronic acid;

(vii) less than 0.0166% N-acetylglucosamine;

(viii) less than 0.00166% amino acids;

(ix) a UV extinction coefficient at 257 nm of less than about 0.23;

(x) a UV extinction coefficient at 280 nm of less than about 0.19; and

(xi) a pH within the range of 7.5 - 7.7.

Other forms of hyaluronic acid and/or its salts, and homologues, derivatives, complexes, esters, fragments and sub units hyaluronic acid may be chosen from other suppliers, for example those described in the prior art documents previously referred to. In addition Applicants have successfully employed sodium hyaluronate produced and supplied by LifeCore™ Biomedical, Inc. having the following specifications

This Sheet Has Been Replaced



Characteristics	Specification
Appearance	White to cream colored particles
Odor	No perceptible Odor
Viscosity Average Molecular Weight	< 750,000 Daltons
UV/Vis Scan, 190-820nm	Matches reference scan
OD, 260nm	< 0.25 OD units
Hyaluronidase Sensitivity	Positive response
IR Scan	Matches reference
pH, 10mg/g solution	6.2 - 7.8
Water	8% maximum
Protein	< 0.3 mcg/mg NaHy
Acetate	< 10.0 mcg/mg NaHy

Heavy Metals, Maximum ppm

As	Cd	Cr	Co	Cu	Fe	Pb	Hg	Ni
2.0	5.0	5.0	10.0	10.0	25.0	10.0	10.0	5.0

Microbial Bioburden	None Observed
Endotoxin	< 0.07 EU/mg NaHy

Biological Safety Testing Passes Rabbit Ocular Toxicity Test

The following references teach hyaluronic acid, sources thereof and processes of the manufacture and recovery thereof.

United States Patent 4,141,973 teaches hyaluronic acid fractions (including sodium salts) having:

> "(a) an average molecular weight greater than about 750,000, preferably greater than about 1,200,000 - that is, a limiting viscosity number greater than about 1400 $cm^3/g.$, and preferably greater than about 2000 $cm^3/g.$;

This Sheet Has Been Replaced



(b) a protein content of less than 0.5% by weight;

(c) ultraviolet light absorbance of a 1% solution of sodium hyaluronate of less than 3.0 at 257 nanometers wavelength and less than 2.0 at 280 nanometers wavelength;

(d) a kinematic viscosity of a 1% solution of sodium hyaluronate in physiological buffer greater than about 1000 centistokes, preferably greater than 10,000 centistokes;

(e) a molar optical rotation of a 0.1 - 0.2% sodium hyaluronate solution in physiolocal buffer of less than -11×10^3 degree - cm^2/mole (of disaccharide) measure at 220 nanometers;

(f) no significant cellular infiltration of the vitreaous and anterior chamber, no flare in the aqueous humor, no haze or flare in the vitreous and no pathological changes to the cornea, lens, iris, retina, and choroid of the owl monkey eye when one milliliter of a 1% solution of sodium hyaluronate dissolved in physiological buffer is implanted in the vitreous replacing approximately one-half the existing liquid vitreous, said HUA being;

(g) sterile and pyrogen free and

(h) non-antigenic."

Canadian Letters Patent 1,205,031 (which refers to United States Patent 4,141,973 as prior art) refers to hyaluronic acid fractions having average molecular weights of from 50,000 to 100,000; 250,000 to 350,000; and 500,000 to 730,000 and discusses processes of their manufacture.

According to yet another aspect of the invention, Alanine Aminotransferase production in damaged tissue, for example the liver is reduced by the administration of, for example hyaluronic acid and/or salts thereof in association with a suitable diluent or pharmaceutically acceptable carrier.

This Sheet Has Been Replaced

This Sheet Has Been Replaced

The following examples are offered to illustrate Applicants' invention but in no way limit the scope of the invention.

Applicants believe that Drug uptake is affected by cellular damage associated with tissue malperfusion. The glycosaminoglycan, Hyaluronic Acid (HA) has been shown to affect cellular membrane activity. To assess its potential effect upon drug uptake we did the following studies. We studied the effect of HA on tritiated 5-Fluorouracil (^{3}H-5-FU) uptake by acute and chronic malperfused rat liver tissue using 2 models.

Example 1 : Ischemia/Reperfusion

Two groups of rats (A,B) were subjected to 30 minute liver ischemia followed by a period of reperfusion. Two sham groups (C, D) served as controls. Two additional groups (E, F) underwent a 'once-through' liver perfusion in order to quantitate tissue bound drug. All groups received intravenous ^{3}H-5-Flourouracil (a radioactive tracer) (^{3}H-5-FU) at the end of the reperfusion period. Groups A, C, and F received in addition intravenous (HA) Hyaluronic Acid (15 mg/kg).

Samples of liver tissue were processed and counted for radioactivity. The groups treated with HA showed a significantly higher (10%, $p<0.05$ ANOVA) uptake of ^{3}H-5-Fu than in the untreated groups. Following 'once through' perfusion the difference between the groups persists.

Example 2 : Liver Tumour (See Figure 1)

Two groups of rats with liver-implanted mammary carcinoma received intravenous ^{3}H-5-FU. One of the groups received intravenous HA as well. Samples of tumour tissue were processed and counted for radioactivity. The uptake ^{3}H-5-FU by tumour tissue was higher (40%, $p<0.05$ ANOVA) in the HA treated group compared to the untreated group.

The results in examples 1 and 2 teach that HA is involved in the observed enhancement of ^{3}H-5-FU uptake by ischemia/reperfused rat liver and by rat liver tumour. It has been previously suggested that the tissue injury or neoplasia may alter local HA production. Applicants have now found that

exogenously given HA preferentially targets such tissues. The following data is offered.

ISCHEMIA		ISCHEMIA +HA	
mean	sem	mean	sem
42952	940	48277	871
43500	847	49130	771
44261	776	41431	1131
44692	648	46140	863
42727	324	43189	950
41288	1793	43911	692
39545	595	45753	614
40544	280	46919	299
42871	1001	43776	535
42487		45392	
569		839	

The following additional data is also offered.

	SUM SQUARES	DEG FREEDOM	MEAN SQUARE
TREATMENT	3.81E+07	1	3.81E+07
ERROR	7.40E+07	16	4622828
TOTAL	1.12E+08		

F-TEST RATIO = 8.232406

SIGNIFICANCE = 0.0111

TREATMENT	MEAN	STANDARD ERROR	NUMBER OF OBSERVATIONS
VAR - 1	42483.67	568.8718	9
VAR - 2	45391.78	838.8565	9

TREATMENT	MEAN	DUNCAN'S MULTIPLE-RANGE TEST
GROUP 1	42483.67	
GROUP 2	45391.78	

STANDARD ERROR OF TREATMENT MEANS = 716.6921

TREATMENT	VS.	TREATMENT	DIFFERENCE	SIG. 0.5	SIG .01
GROUP 1		GROUP 2	2908.109	*	-

TREATMENT	MEANS	NEWMAN-KEULS' MULTIPLE-RANGE TEST
GROUP 1	42483.67	
GROUP 2	45391.78	

This Sheet Has Been Replaced



STANDARD ERROR OF TREATMENT MEANS = 716.6921

TREATMENT	VS.	TREATMENT	DIFFERENCE	SIG .05	SIG .01
GROUP 1		GROUP 2	2908.109	*	-

TREATMENT	MEAN	DUNNETT'S MULTIPLE-RANGE TEST
GROUP 1	42483.67	
GROUP 2	45391.78	

STANDARD ERROR OF TREATMENT MEANS = 1013.556

TREATMENT	VS.	TREATMENT	DIFFERENCE	SIG .05	SIG .01
GROUP 1		GROUP 2	2908.109	*	-

TREATMENT	MEAN	LEAST SIGNIFICANT DIFFERENCE MULTIPLE-RANGE TEST
GROUP 1	42483.67	
GROUP 2	45391.78	

STANDARD ERROR OF TREATMENT MEANS = 716.6921

TREATMENT	VS.	TREATMENT	DIFFERENCE	SIG .05
GROUP 1		GROUP 2	2908.109	*

Example 3

Alanine Aminotransferase (ALT) is an enzyme released by the liver when the liver is damaged or when experiencing ischemia. The lower the level of released ALT, the lower the level of damage. Two groups of rats underwent liver ischemia by clamping off the hepatic artery to the liver for 30 minutes followed by a period of reperfusion. One group was given intravenously a control injection whereas the other group was given HA (Sodium hyaluronate) intravenously. Both groups were measured for Alanine Aminotransferase levels. The group which received HA demonstrated significantly lower levels of Alanine Aminotransferase enzyme in the blood stream compared to the control groups.

This Sheet Has Been Replaced



ALT (Alanine Aminotransferase) Measurement in Ischemia/Reperfusion Rats (Blood Stream).

			Absolute value			Expressed as percentage of baseline			
Group 1	rat#	Baseline		30'	72hrs	Baseline	30'		72hrs
+HA		1	80	592		137	740		171
		3	173	518			299		
		5	80	264		47	330		59
		7	89	310		40	348		45
		9	59	484		43	820		73
		11	87	323			371		
	mean		94.67	415.75		66.75	484.89	86.96	
	sed		16.26	54.46		23.46	94.44	28.67	
Group 2	rat#								
		2	86	1420		84	1651		98
		4	90	603		70	670		78
		6	57	361			633		
		8	78	2010		92	2577		118
		10	64	1040			1625		
	mean		75	1086.6		82	1431.28		97.80
	sed		6.32	293.80		6.43	361.57		11.60

(SEE FIGURE 2)

Further test data is set out below:
(See Figure 3)

Alanine Transferase Measurement in Ischemia Rats [Blood Stream];

RAT #	PREOP	POSTOP 0'	POSTOP 30'	POSTOP 60'	POP 0'%	POP 30' %	POP 60'%
1	67	229	1289	2030	342	1924	3030
2	73	279	1220	2120	382	1671	2904
3	76	890	1310	2020	1171	1724	2658
4	74	395	1070	1160	534	1446	1568
5	78	158	1080	1390	203	1385	1782
6	68	215	1170	2840	316	1721	4176
7	81	272	1140	1670	336	1407	2062
MEAN		348.29	1182.71	1890.00	469.05	1611.05	2597.10
SEM		101.99	38.78	225.04	132.59	82.69	364.79
8	98	478	1860	2940	488	1898	3000
9	83	190	2020	2600	229	2434	3133
10	89	436	2930	3400	490	3292	3820
11	105	590	1930	2600	562	1838	2476
12	88	277	2020	3400	315	2295	3864
13	91	220	2170	3710	242	2385	4077
14	98	343	1730	1940	350	1765	1980
MEAN	83.5	362.00	2094.29	2941.43	382.14	2272.47	3192.73
SEM		59.69	160.71	249.85	53.71	215.06	318.48

MEAN COMPARISON

	HA	CONTROL
postop 0'	348	362
postop 30'	1183	2094
postop 60'	1890	2941
postop 0'	469	382
postop 30'	1611	2272
postop 60'	2597	3193

This Sheet Has Been Replaced



Example 4 **HYALURONIC ACID (HA) ENHANCED ^{3}H-5-FLUOROURACIL UPTAKE IN THE MALPERFUSED RAT LIVER**

Purpose: To assess the effect of HA on tritiated 5-Fluorouracil (^{3}H-5-Fu) uptake by acute and chronic malperfused rat liver tissue created in two surgical animal models.

1. Experiment model 1: Hepatic Ischemia/reperfusion.

Four groups of rats (A, B, C, D) were subjected to a 45 minute liver ischemia produced by clamping the hilus of the liver followed by a period of 60 minutes of reperfusion. Two sham (E, F) groups went through the same procedure except that the clamping time was not over 15 seconds and served as controls. All groups received intravenous (i.v.) ^{3}H-5-Fu (10 μCi/kg, Sigma) at the end of reperfusion period without (A, C, E) or with (B, D, F) i.v. HA (15mg/kg, Hyal). Groups C and D also underwent a "once-through" liver perfusion with normal saline to eliminate blood factor. Liver samples were collected ten minutes after the injection of ^{3}H-5-Fu and prepared for radioactivity counting.

2. Experiment model II: Liver-implanted tumour:

A single cell suspension containing half million rat Mammary Carcinoma cells per 0.1 ml was injected underneath the capsule of the left lobe of liver. This inoculation would grow within the liver tissue up to a single nodule, which would be with a diameter of 1 to 1.25 cm and weigh about 1 to 1.5 grams in about two weeks. Two groups of rats bearing two-week-old liver-implanted rat mammary carcinoma received i.v. ^{3}H-5-Fu alone or combined with i.v. HA Liver (LVR) and tumour (TMR) tissues were harvested ten minutes after and processed for radioactivity counting.

This Sheet Has Been Replaced

Results: All the results were expressed as means of the counting plus and minus standard error. Statistics were done by using one way ANOVA to process the data.

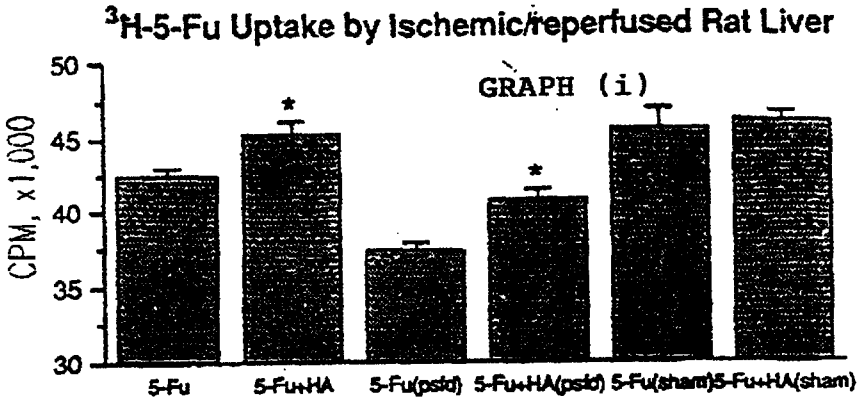
Table 1: *Hepatic ischemia/reperfusion model*

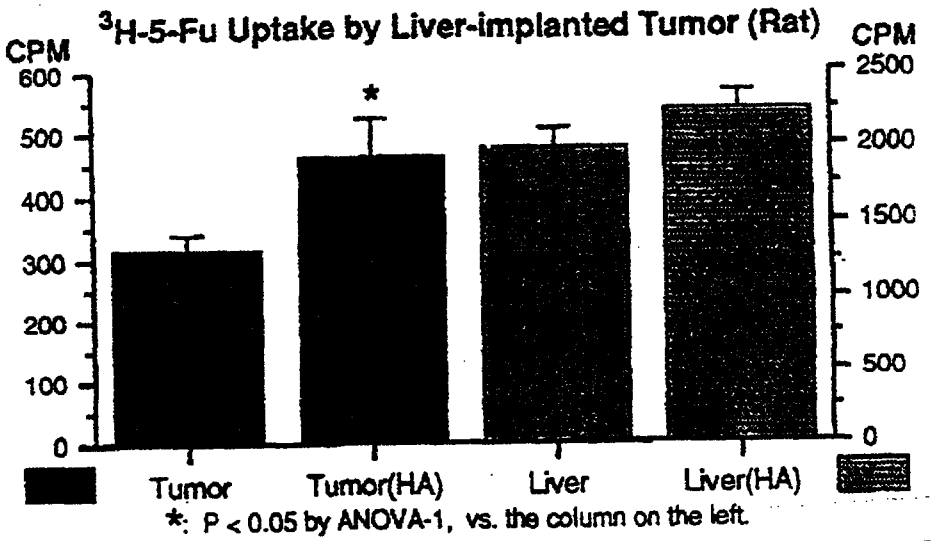
Group(n=)	A(9)	B(9)	C(9)	D(6)	E(8)	F(9)
meansCPM	42487	45392*	37372	40790*	45591	46261
SEM	±569	±839	±468	±665	±1328	±536

Table 2: *Liver-implanted tumour model*

Tissue(n=)	TMR(9)	TMR(HA)(9)	LVR(9)	LVR(HA)(9)
meanCPM	314	461*	1979	2237
SEM	±25	±61	±133	±122

In the results, * means P<0.05 by ANOVA-1, vs. untreated groups. CPM=count per minute; SEM=standard error.





This Sheet Has Been Replaced

It is apparent from the above graphs (i) and (ii) that the exogenous HA significantly enhanced the uptake or distribution of ^{3}H-5-Fu in the ischemic/reperfused liver tissue and liver-implanted tumour tissue.

Example 5 **HA Distribution in The Liver of Hepatic Ischemia/reperfusion Rats**

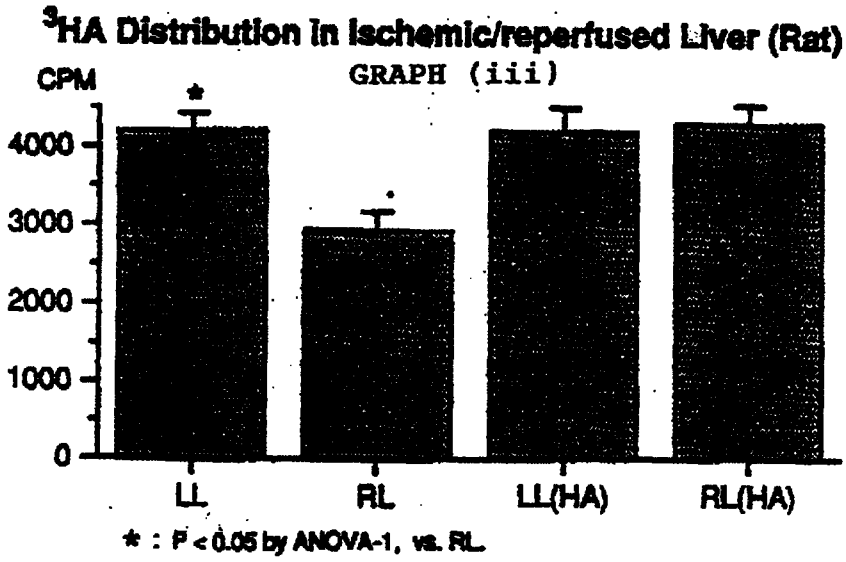
In our previous examples, we have confirmed that the exogenous HA can enhance the uptake or distribution of certain pharmaceutics. What we still do not know is the distribution of HA itself under the pathological situation. Therefore, we design this experiment to reveal the picture of HA distribution in a ischemic/reperfused rat model.

Animal: Fischer 344, male, 200 gm of body weight.

Two groups of rats were subjected to a 60 minute liver ischemia produced by clamping the left side of hilus of liver followed by period of 30 minutes reperfusion. Then all the animals received an injection of either exogenous HA (15 mg/kg) or same amount of normal saline through peripheral vein. Ten minutes later, tritium labeled HA (20 μCi/kg) was given intravenously. After another five minutes, pieces of tissue were harvested from right and left lobes of liver separately and processed for β counting.

As can be seen from graph (iii) below without the exogenous cold HA, the damaged side of the liver contained significantly higher counting compared with the right lobe. When the liver was preloaded with cold HA, however, no significant difference was shown in the counts of both sides.

This Sheet Has Been Replaced



As many changes can be made to the preferred embodiments of the invention without departing from the scope of the invention; it is intended that all material herein be treated as illustrative of the invention and not in a limiting sense.

This Sheet Has Been Replaced

This Sheet Has Been Replaced

CLAIMS

1. A pharmaceutical composition comprising an effective non-toxic amount of hyaluronic acid (HA) and or salts thereof and/or homologues, analogues, derivatives, complexes, esters, fragments and units of HA in association with a suitable diluent or pharmaceutically acceptable carrier for use in treating ischemia damage in tissue.

2. The pharmaceutical composition of claim 1 wherein the amount of hyaluronic acid is selected from hyaluronic acid and salts thereof.

3. The pharmaceutical composition of claim 2 for treating ischemia damage in tissue through reperfusion or the like.

4. The pharmaceutical composition of claim 2 for use in treating ischemia damage in internal organs.

5. The pharmaceutical composition of claim 2 for use in treating ischemia damage in the liver.

6. The pharmaceutical composition of claim 2 for use in treating ischemia damage in the kidneys.

7. The pharmaceutical composition of claim 2 for use in treating ischemia damage in the heart.

8. The pharmaceutical composition of claims 2 or 4 where said treatment comprises reperfusion.

* C L M S *

This Sheet Has Been Replaced

9. The pharmaceutical composition of claims 5, 6 or 7 where said treatment comprises reperfusion.

10. The pharmaceutical composition of claim 2 for use in treating ischemia damage in tissue during transplantation.

11. The pharmaceutical composition of claim 2 for use in treating ischemia damage in tissue during transplantation of internal organs.

12. The pharmaceutical composition of claim 2 for use in treating ischemia damage in tissue during transplantation of the liver.

13. The pharmaceutical composition of claim 2 for use in treating ischemia damage in tissue during transplantation of the kidney or kidneys.

14. The pharmaceutical composition of claim 2 for use in treating ischemia damage in tissue during transplantation of the heart.

15. The pharmaceutical composition of claims 1-14 inclusive wherein the amount of hyaluronic acid or forms thereof is between about 300 mg to about 7 grams.

16. A formulation for reducing Alanine Aminotransferase enzyme production by a liver when damaged or is experiencing ischemia, said formulation comprising an effective non-toxic amount of hyaluronic acid and/or salts thereof in association with a suitable diluent or pharmaceutically acceptable carrier.

* C L M S *

This Sheet Has Been Replaced

17. The use of a pharmaceutical composition for use in treating ischemia damage in tissue, the use comprising administering an effective non-toxic amount of hyaluronic acid and/or salts thereof and/or homologues, analogues, derivatives, complexes, ester, fragments and units of hyaluronic acid for treating ischemia damage in tissue, in association with a suitable diluent or pharmaceutically acceptable carrier.

18. The use of a pharmaceutical composition for treating ischemia damage in tissue comprising an effective non-toxic amount of hyaluronic acid and/or salts thereof for treating ischemia damage in tissue in association with a suitable diluent or pharmaceutically acceptable carrier.

19. The use of claim 17 wherein the amount of the form of hyaluronic acid administered is between about 300 mg and about 7 grams/70 kg person per day.

20. The use of claim 18 wherein the amount of hyaluronic acid or salt thereof administered is between about 300 mg and about 7 grams/70 kg person per day.

21. The use of the pharmaceutical composition of claim 18 or 20 wherein the tissue is selected from the internal organs.

22. The use of the pharmaceutical composition of claim 18 or 20 wherein the tissue is the liver.

23. The use of the pharmaceutical composition of claim 18 or 20 wherein the tissue is the kidneys.

* C L M S *

24. The use of the pharmaceutical composition of claim 18 or 20 wherein the tissue is the heart.

25. The use of the pharmaceutical composition of claim 18 or 20 wherein the composition is used for treating or preventing ischemia damage in tissue during transplantation.

26. The use of the pharmaceutical composition of claim 18 or 20 wherein the composition is used for treating or preventing ischemia damage in tissue during transplantation of internal organs.

27. The use of the pharmaceutical composition of claim 18 or 20 wherein the composition is used for treating or preventing ischemia damage in tissue during transplantation of the liver.

28. The use of the pharmaceutical composition of claim 18 or 20 wherein the composition is used for treating or preventing ischemia damage in tissue during transplantation of the kidney or kidneys.

29. The use of the pharmaceutical composition of claim 18 or 20 wherein the composition is used for treating or preventing ischemia damage in tissue during transplantation of the heart.

30. The use of a formulation for the medical treatment of reducing Alanine Aminotransferase enzyme production by a liver when damaged or experiencing ischemia comprising administering a formulation comprising an effective non-toxic amount of hyaluronic acid and/or salts thereof in association with a suitable diluent or pharmaceutically acceptable carrier to the liver.

This Sheet Has Been Replaced

31. The use of claim 30 wherein the amount of hyaluronic acid and/or salts thereof is from about 300 mg to about 7 grams/70 kg person per day.

32. The formulation of claim 16 wherein the amount of hyaluronic acid and/or salts thereof is from between about 300 mg to about 7 grams.

33. The pharmaceutical composition of claim 2 for use in treating ischemia damage in the lungs.

34. The use of the pharmaceutical composition of claim 18 or 20 wherein the tissue is the lungs.

35. The use of the pharmaceutical composition of claim 18 or 20 wherein the composition is used for treating or preventing ischemia damage in tissue during the transplantation of the lungs.

* C L M S *

This Sheet Has Been Replaced

ABSTRACT

THE USE OF HYALURONIC ACID TO REPAIR ISCHEMIA REPERFUSION DAMAGE.

A pharmaceutical composition comprising an effective non-toxic amount of hyaluronic acid (HA) and or salts thereof and/or homologues, analogues, derivatives, complexes, esters, fragments and units of HA in association with a suitable diluent or pharmaceutically acceptable carrier for use in treating ischemia damage in tissue.

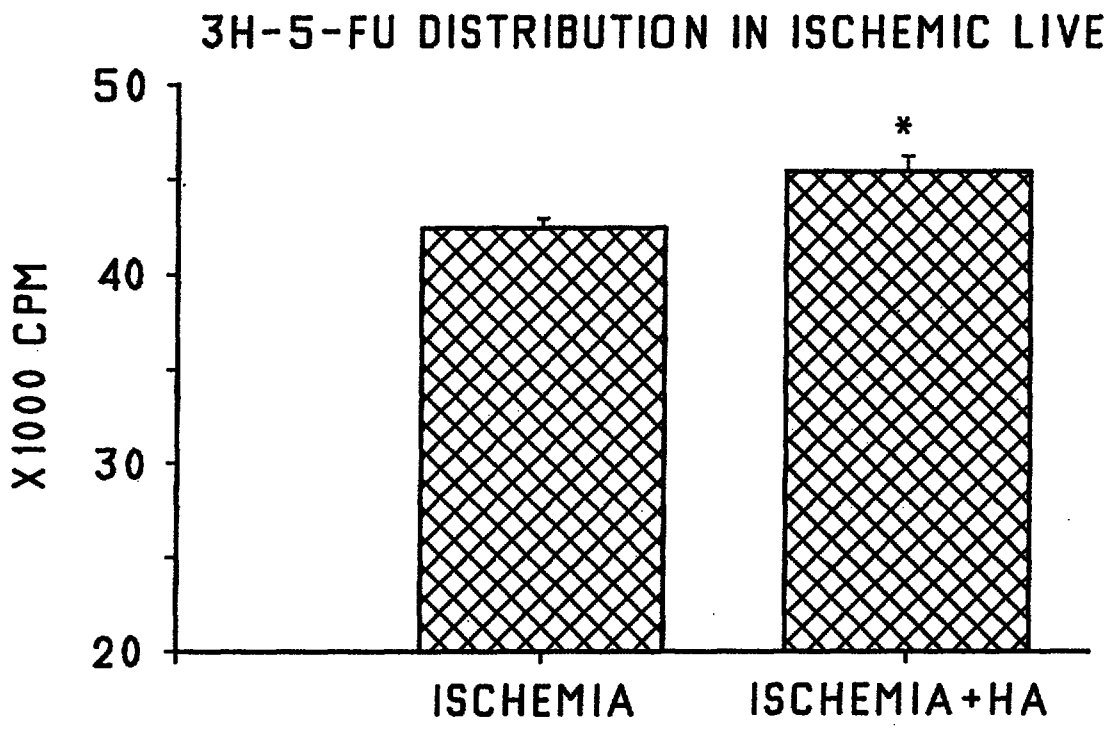


FIG.1.

This Sheet Has Been Replaced

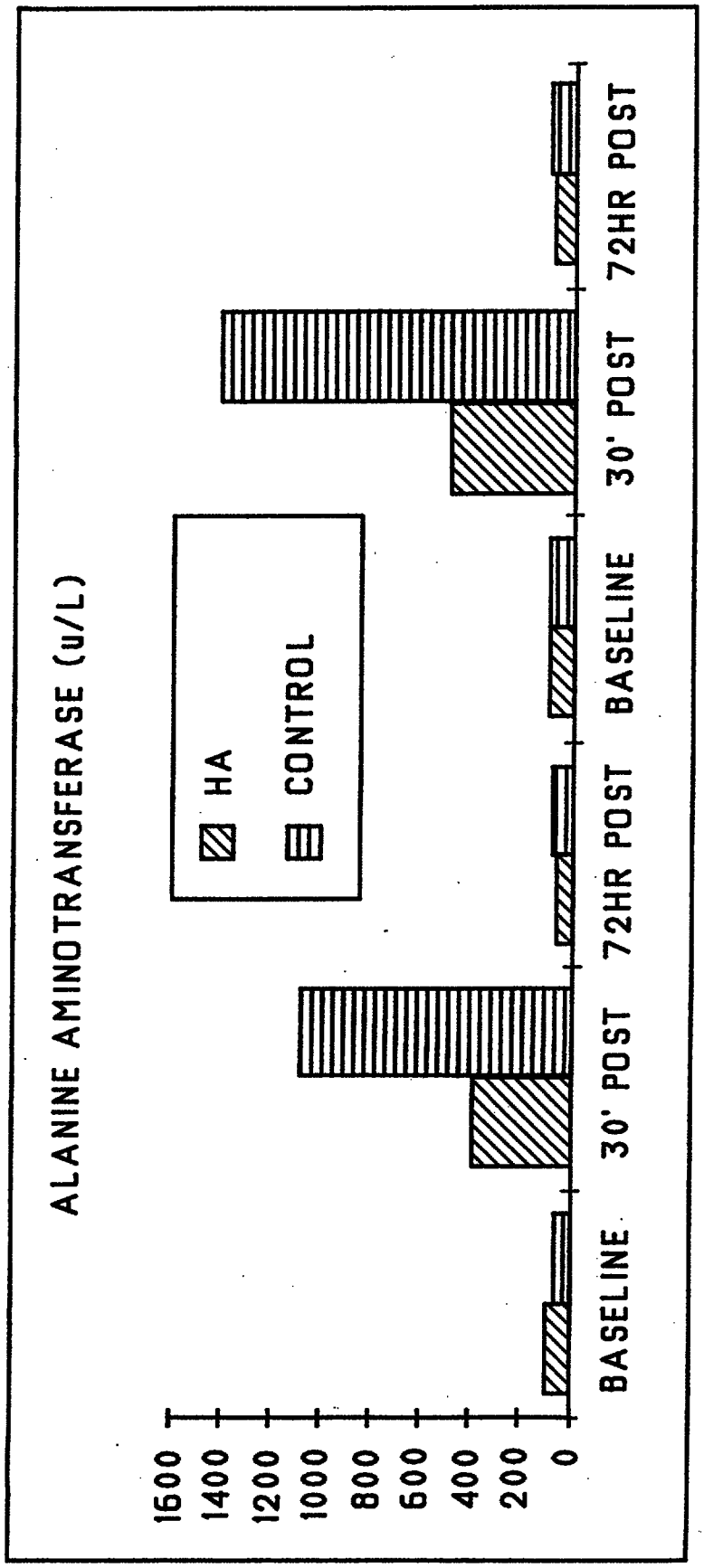


FIG.2.

This Sheet Has Been Replaced

This Sheet Has Been Replaced

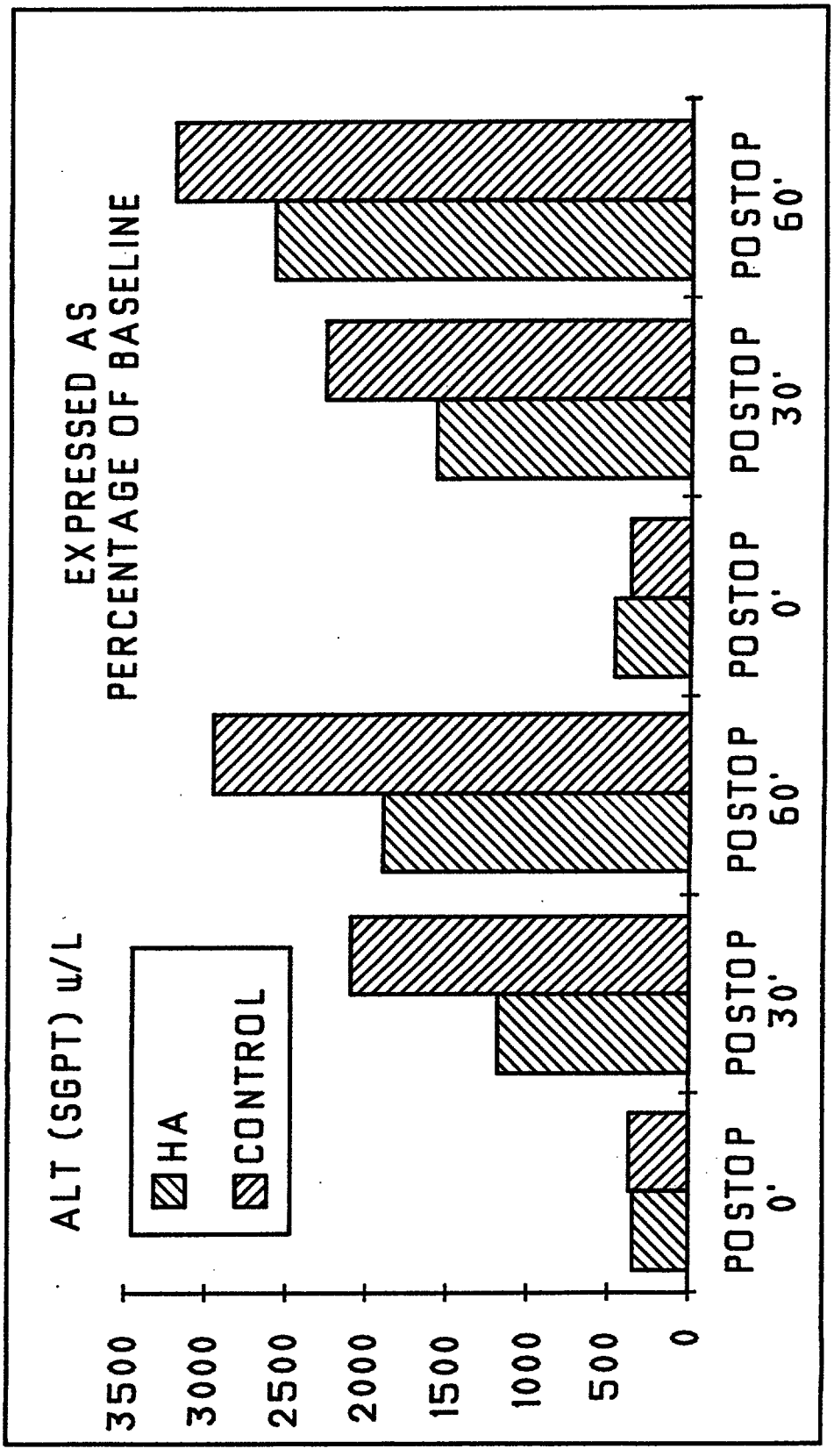
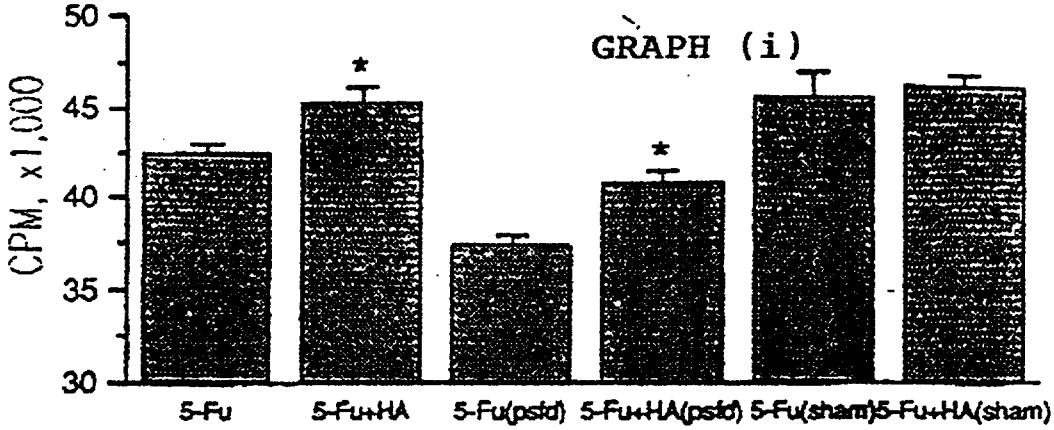


FIG.3.

This Sheet Has Been Replaced

^{3}H-5-Fu Uptake by Ischemic/reperfused Rat Liver

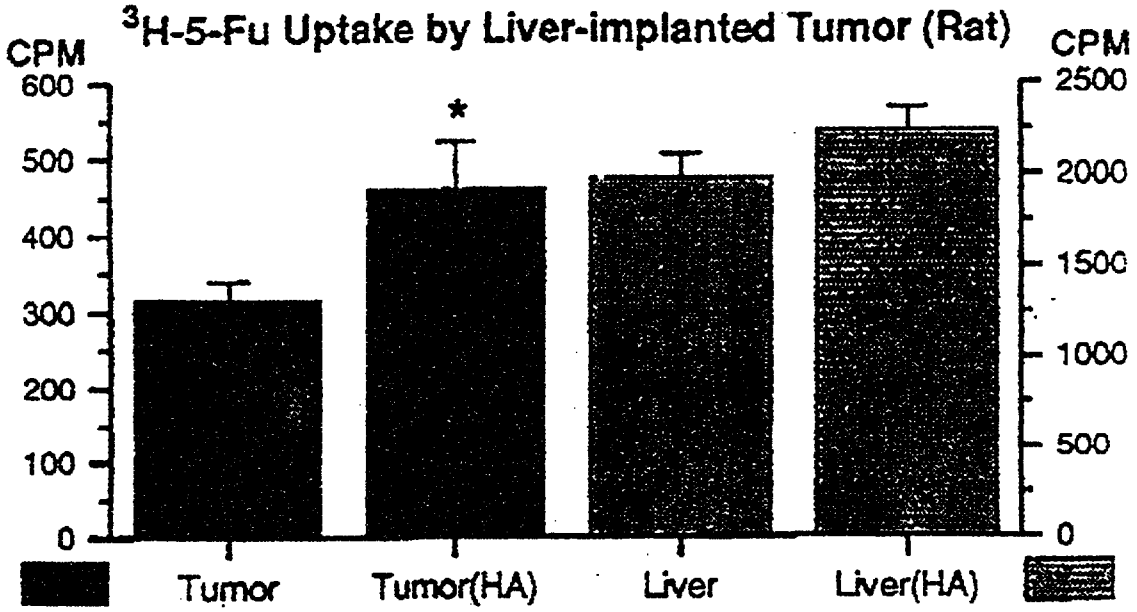
GRAPH (i)



* : P < 0.05 by ANOVA-1, vs. columns on the left.

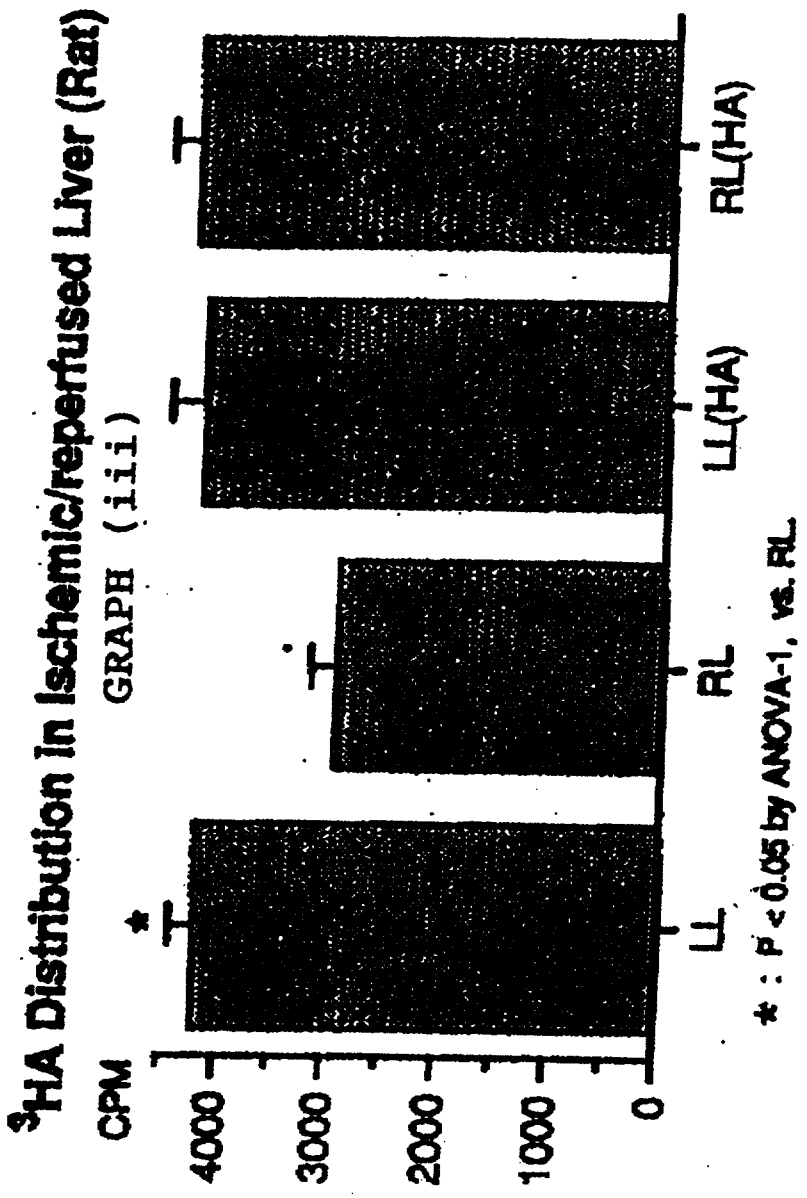
GRAPH (ii)

^{3}H-5-Fu Uptake by Liver-implanted Tumor (Rat)



*: P < 0.05 by ANOVA-1, vs. the column on the left.

This Sheet Has Been Replaced



REPLACED SHEETS SG
☐ Description : paged ..... to paged .....
☑ Claim(s) : paged ..18.... to paged ..20....
☐ Drawing(s) : paged ..... to paged .....
☐ Abstract : paged ..... to paged .....
DATE OF RECEIPT .....

REPLACEMENT SHEETS SG
☑ Description : paged ..1.. to paged ..15..
☑ Claim(s) : paged ..16.. to paged ..20..
☑ Drawing(s) : paged ..4/5.. to paged ..5/5..
☑ Abstract : paged ..21.. to paged ..22..
DATE OF RECEIPT ..21/8/96..

TITLE OF THE INVENTION

THE USE OF HYALURONIC ACID TO REPAIR ISCHEMIA REPERFUSION DAMAGE

FIELD OF INVENTION

This invention relates to repair through reperfusion of ischemia damage to tissue particularly internal organs and most particularly to the liver, heart, and kidneys and formulations for use to repair through reperfusion such ischemia damage and methods of treating such conditions.

BACKGROUND OF THE INVENTION

United States Patent 4,801,619 relates to hyaluronic acid administered intra-articularly having a molecular weight of about 3 X 10^6 dalton more, which is prone to decrease the proteoglycan content of synovial fluid to almost normal levels. According to this patent, this indicates a positive effect on the proteoglycan metabolism of a joint. According to the Patent this is applicable both to inflammatory conditions and to degeneration caused by treatment with symptomatics, such as corticosteroid preparations. It is thus clear that a sufficiently high molecular weight of the hyaluronic acid is alleged to counteract side effects that might be caused by corticosteroids or other symptomatics producing similar effects. When corticosteroids are applied, the amount of hyaluronic acid in the synovial cavity will according to the Patent increase substantially and according to the inventors their hyaluronic acid preparations have a very positive effect on such clinical symptoms as pain, swelling and lameness.

The patent states that the objectives of the invention are attained by intra-articular administration of an effective amount of hyaluronic acid with a mean molecular weight exceeding 3 X 10^6 dalton, preferably exceeding 4 X 10^6 dalton; usually the molecular weight will not exceed 7 X 10^6 dalton. The dosage of hyaluronic acid administered is stated to be preferably within the range of 5mg-80mg. The amount of solution given at each administration is generally less than 60 ml, e.g. less that 20 ml, of an aqueous solution of the acid or its salt. It is convenient to administer the acid dissolved in water (<2% w/w, buffered to physiological pH), for instance in the form of a water-

This is the replacement sheet

Date: 21 AUG 1996

soluble sodium salt. The exact amount will depend on the particular joint to be treated.

The Merck Index specifies that hyaluronic acid has a molecular weight within the range pf 50,000 to 8 X 10^6 depending on source, methods of preparation and methods of determination. The Merck Publication teaches hyaluronic acid as a surgical aid (ophthalmological).

United States Patent 4,808,576 purports to teach that hyaluronic acid, an agent well known to reduce the sequelae of trauma in mammalian joint tissue when applied directly to the traumatized tissue, will be carried to such traumatized tissue by the mammal's natural processes if applied at a site remote from the traumatized tissue. Thus hyaluronic acid in any therapeutically acceptable form can, according to the Patent, be administered by the typical remote routes including intravenous, intramuscular, subcutaneous and topical.

This, the patent alleges, makes the utilization of hyaluronic acid much more convenient and attractive. For instance the treatment of arthritis in horse or human joints with hyaluronic acid according to the patent no longer requires more difficult intra articular injections.

United States Patent 4,725,585 relates to a method of enhancing or regulating the host defence of a mammal, said method comprising administering to a mammal a therapeutically effective amount of hyaluronic acid.

At column 1 lines 43 - 46, the patent provides that the invention was based on the unexpected discovery that administration of hyaluronic acid to mammals results in a considerable increase in the defence.

We have now discovered that hyaluronic acid and its salts and other forms are useful in repairing ischemia reperfusion damage in tissue particularly internal organs and most particularly the liver.

This is the replacement sheet
Date: 21 AUG 1996

SUMMARY OF THE INVENTION

According to one aspect of the invention, a formulation for administration to a mammal is provided comprising an amount of hyaluronic acid and or salts thereof and/or homologues, analogues, derivatives, complexes, esters, fragments and sub units of hyaluronic acid effective to prevent or repair ischemia reperfusion damage in tissue particularly internal organs for example the liver, together with a pharmaceutical carrier.

The hyaluronic acid in a carrier may be administered intravenously, by infusion or any other suitable method and may be administered up to about 7gm per 70 kg person per day. While reduced amounts of hyaluronic acid may be delivered in the carrier it is preferable that the least amount of hyaluronic acid be in the range of about 300mg/70kg person per day.

According to another aspect of the invention, a method of repairing ischemia reperfusion damage in tissue, particularly internal organs, and more particularly the liver, is provided comprising administering to the mammal a therapeutically effective amount of hyaluronic acid and or salts thereof and/or homologues, analogues, derivatives, complexes, esters, fragments and sub units of hyaluronic acid in a suitable carrier. Because hyaluronic acid targets the damaged tissue and facilitates its own penetration through the tissue at the site to be treated through the cell membranes into the individual cells to be treated, it rapidly arrives at the site after introduction, for example, by intravenous methods and repairs the ischemia reperfusion damage in the tissue, for example the liver, or prevents or minimizes such damage (as for example in transplants such as the liver, heart, lungs, and kidneys).

The formulation can be administered among other methods, intravenously, intra-arterially, intraperitoneally, intrapleurally, transdermally, on the skin, or by direct injection (for example into the liver).

This is the replacement sheet
21 AUG 1996
Date:

One form of hyaluronic acid and/or salts thereof (for example sodium salt) and homologues, analogues, derivatives, complexes, esters, fragments and sub units of hyaluronic acid, preferably hyaluronic acid and salts and thereof suitable for use with Applicant's invention is a fraction suppled by Hyal Pharmaceuticals Limited. One such fraction is a 15 ml vial of Sodium hyaluronate 20mg/ml (300mg/vial - Lot 2F3). The sodium hyaluronate fraction is a 2% solution with a mean average molecular weight of about 225,000. The fraction also contains water q.s. which is triple distilled and sterile in accordance with the U.S.P. for injection formulations. The vials of hyaluronic acid and/or salts thereof may be carried in Type I borosilicate g vial closed by a butyl stopper which does not react with the contents of the vial.

The fraction of hyaluronic acid and/or salts thereof (for example sodium salt) and homologues, analogues, derivatives, complexes, esters, fragments and sub units of hyaluronic acid, preferably hyaluronic acid and salts and thereof may comprise hyaluronic acid and/or salts thereof having the following characteristics:

a purified, substantially pyrogen-free fraction of hyaluronic acid obtained from a natural source having at least one characteristic selected from the group consisting of the following:

(i) a molecular weight within the range of 150,000 -700,000;

(ii) less than about 1.25% sulphated mucopolysaccharides on a total weight basis;

(iii) less than about 0.6% protein on a total weight basis;

(iv) less than about 150 ppm iron on a total weight basis;

(v) less than about 15 ppm lead on a total weight basis;

(vi) less than 0.0025% glucosamine;

(vii) less than 0.025% glucuronic acid;

(viii) less than 0.025% N-acetylglucosamine;

(ix) less than 0.0025% amino acids;

This is the replacement sheet

Date: 21 AUG 1996

(x) a UV extinction coefficient at 257 nm of less than about 0.275;

(xi) a UV extinction coefficient at 280nm of less than about 0.25; and

(xii) a pH within the range of 7.3 - 7.9.

Preferably the hyaluronic acid is mixed with water and the fraction of hyaluronic acid fraction has a mean average molecular weight within the range of 150,000 - 225,000. More preferably the fraction of hyaluronic acid comprises at least one characteristic selected from the group consisting of the following characteristics:

(i) less than about 1% sulphated mucopolysaccharides on a total weight basis;

(ii) less than about 0.4% protein on a total weight basis;

(iii) less than about 100 ppm iron on a total weight basis;

(iv) less than about 10 ppm lead on a total weight basis;

(v) less than 0.00166% glucosamine;

(vi) less than 0.0166% glucuronic acid;

(vii) less than 0.0166% N-acetylglucosamine;

(viii) less than 0.00166% amino acids;

(ix) a UV extinction coefficient at 257 nm of less than about 0.23;

(x) a UV extinction coefficient at 280 nm of less than about 0.19; and

(xi) a pH within the range of 7.5 - 7.7.

Other forms of hyaluronic acid and/or its salts, and homologues, derivatives, complexes, esters, fragments and sub units hyaluronic acid may be chosen from other suppliers, for example those described in the prior art documents previously referred to. In addition Applicants have successfully employed sodium hyaluronate produced and supplied by LifeCore™ Biomedical, Inc. having the following specifications

This is the replacement sheet

Date: 21 AUG 1996

Characteristics	Specification
Appearance	White to cream colored particles
Odor	No perceptible Odor
Viscosity Average Molecular Weight	< 750,000 Daltons
UV/Vis Scan, 190-820nm	Matches reference scan
OD, 260nm	< 0.25 OD units
Hyaluronidase Sensitivity	Positive response
IR Scan	Matches reference
pH, 10mg/g solution	6.2 - 7.8
Water	8% maximum
Protein	< 0.3 mcg/mg NaHy
Acetate	< 10.0 mcg/mg NaHy

Heavy Metals, Maximum ppm

As	Cd	Cr	Co	Cu	Fe	Pb	Hg	Ni
2.0	5.0	5.0	10.0	10.0	25.0	10.0	10.0	5.0

Microbial Bioburden	None Observed
Endotoxin	< 0.07 EU/mg NaHy

Biological Safety Testing Passes Rabbit Ocular Toxicity Test

The following references teach hyaluronic acid, sources thereof and processes of the manufacture and recovery thereof.

United States Patent 4,141,973 teaches hyaluronic acid fractions (including sodium salts) having:

> "(a) an average molecular weight greater than about 750,000, preferably greater than about 1,200,000 - that is, a limiting viscosity number greater than about 1400 $cm^3/g.$, and preferably greater than about 2000 $cm^3/g.$;

This is the replacement sheet

Date: 2 1 AUG 1996

(b) a protein content of less than 0.5% by weight;

(c) ultraviolet light absorbance of a 1% solution of sodium hyaluronate of less than 3.0 at 257 nanometers wavelength and less than 2.0 at 280 nanometers wavelength;

(d) a kinematic viscosity of a 1% solution of sodium hyaluronate in physiological buffer greater than about 1000 centistokes, preferably greater than 10,000 centistokes;

(e) a molar optical rotation of a 0.1 - 0.2% sodium hyaluronate solution in physiolocal buffer of less than -11 X 10^3 degree - cm^2/mole (of disaccharide) measure at 220 nanometers;

(f) no significant cellular infiltration of the vitreaous and anterior chamber, no flare in the aqueous humor, no haze or flare in the vitreous and no pathological changes to the cornea, lens, iris, retina, and choroid of the owl monkey eye when one milliliter of a 1% solution of sodium hyaluronate dissolved in physiological buffer is implanted in the vitreous replacing approximately one-half the existing liquid vitreous, said HUA being;

(g) sterile and pyrogen free and

(h) non-antigenic."

Canadian Letters Patent 1,205,031 (which refers to United States Patent 4,141,973 as prior art) refers to hyaluronic acid fractions having average molecular weights of from 50,000 to 100,000; 250,000 to 350,000; and 500,000 to 730,000 and discusses processes of their manufacture.

According to yet another aspect of the invention, Alanine Aminotransferase production in damaged tissue, for example the liver is reduced by the administration of, for example hyaluronic acid and/or salts thereof in association with a suitable diluent or pharmaceutically acceptable carrier.

This is the replacement sheet

Date: 21 AUG 1996

The following examples are offered to illustrate Applicants' invention but in no way limit the scope of the invention.

Applicants believe that Drug uptake is affected by cellular damage associated with tissue malperfusion. The glycosaminoglycan, Hyaluronic Acid (HA) has been shown to affect cellular membrane activity. To assess its potential effect upon drug uptake we did the following studies. We studied the effect of HA on tritiated 5-Fluorouracil (^{3}H-5-FU) uptake by acute and chronic malperfused rat liver tissue using 2 models.

Example 1 : Ischemia/Reperfusion

Two groups of rats (A,B) were subjected to 30 minute liver ischemia followed by a period of reperfusion. Two sham groups (C, D) served as controls. Two additional groups (E, F) underwent a 'once-through' liver perfusion in order to quantitate tissue bound drug. All groups received intravenous ^{3}H-5-Flourouracil (a radioactive tracer) (^{3}H-5-FU) at the end of the reperfusion period. Groups A, C, and F received in addition intravenous (HA) Hyaluronic Acid (15 mg/kg).

Samples of liver tissue were processed and counted for radioactivity. The groups treated with HA showed a significantly higher (10%, $p<0.05$ ANOVA) uptake of ^{3}H-5-Fu than in the untreated groups. Following 'once through' perfusion the difference between the groups persists.

Example 2 : Liver Tumour (See Figure 1)

Two groups of rats with liver-implanted mammary carcinoma received intravenous ^{3}H-5-FU. One of the groups received intravenous HA as well. Samples of tumour tissue were processed and counted for radioactivity. The uptake ^{3}H-5-FU by tumour tissue was higher (40%, $p<0.05$ ANOVA) in the HA treated group compared to the untreated group.

The results in examples 1 and 2 teach that HA is involved in the observed enhancement of ^{3}H-5-FU uptake by ischemia/reperfused rat liver and by rat liver tumour. It has been previously suggested that the tissue injury or neoplasia may alter local HA production. Applicants have now found that

This is the replacement sheet

Date: 21 AUG 1996

exogenously given HA preferentially targets such tissues. The following data is offered.

ISCHEMIA		ISCHEMIA +HA	
mean	sem	mean	sem
42952	940	48277	871
43500	847	49130	771
44261	776	41431	1131
44692	648	46140	863
42727	324	43189	950
41288	1793	43911	692
39545	595	45753	614
40544	280	46919	299
42871	1001	43776	535
42487		45392	
569		839	

The following additional data is also offered.

	SUM SQUARES	DEG FREEDOM	MEAN SQUARE
TREATMENT	3.81E+07	1	3.81E+07
ERROR	7.40E+07	16	4622828
TOTAL	1.12E+08		

F-TEST RATIO = 8.232406

SIGNIFICANCE = 0.0111

TREATMENT	MEAN	STANDARD ERROR	NUMBER OF OBSERVATIONS
VAR - 1	42483.67	568.8718	9
VAR - 2	45391.78	838.8565	9

TREATMENT	MEAN	DUNCAN'S MULTIPLE-RANGE TEST
GROUP 1	42483.67	
GROUP 2	45391.78	

STANDARD ERROR OF TREATMENT MEANS = 716.6921

TREATMENT	VS.	TREATMENT	DIFFERENCE	SIG .05	SIG .01
GROUP 1		GROUP 2	2908.109	*	-

TREATMENT	MEANS	NEWMAN-KEULS' MULTIPLE-RANGE TEST
GROUP 1	42483.67	
GROUP 2	45391.78	

This is the replacement sheet

Date: 21 AUG 1996

STANDARD ERROR OF TREATMENT MEANS = 716.6921

TREATMENT	VS.	TREATMENT	DIFFERENCE	SIG .05	SIG .01
GROUP 1		GROUP 2	2908.109	*	-

TREATMENT	MEAN	DUNNETT'S MULTIPLE-RANGE TEST
GROUP 1	42483.67	
GROUP 2	45391.78	

STANDARD ERROR OF TREATMENT MEANS = 1013.556

TREATMENT	VS.	TREATMENT	DIFFERENCE	SIG .05	SIG .01
GROUP 1		GROUP 2	2908.109	*	-

TREATMENT	MEAN	LEAST SIGNIFICANT DIFFERENCE MULTIPLE-RANGE TEST
GROUP 1	42483.67	
GROUP 2	45391.78	

STANDARD ERROR OF TREATMENT MEANS = 716.6921

TREATMENT	VS.	TREATMENT	DIFFERENCE	SIG .05
GROUP 1		GROUP 2	2908.109	*

Example 3

Alanine Aminotransferase (ALT) is an enzyme released by the liver when the liver is damaged or when experiencing ischemia. The lower the level of released ALT, the lower the level of damage. Two groups of rats underwent liver ischemia by clamping off the hepatic artery to the liver for 30 minutes followed by a period of reperfusion. One group was given intravenously a control injection whereas the other group was given HA (Sodium hyaluronate) intravenously. Both groups were measured for Alanine Aminotransferase levels. The group which received HA demonstrated significantly lower levels of Alanine Aminotransferase enzyme in the blood stream compared to the control groups.

This is the replacement sheet

Date: 21 AUG 1996

ALT (Alanine Aminotransferase) Measurement in Ischemia/Reperfusion Rats (Blood Stream).

		Absolute value				Expressed as percentage of baseline			
Group 1	rat#	Baseline		30'	72hrs	Baseline	30'		72hrs
+HA	1	80		592		137	740		171
	3	173		518			299		
	5	80		264		47	330		59
	7	89		310		40	348		45
	9	59		484		43	820		73
	11	87		323			371		
	mean		94.67	415.75		66.75	484.89	86.96	
	sed		16.26	54.46		23.46	94.44	28.67	
Group 2	rat#								
	2	86		1420		84	1651		98
	4	90		603		70	670		78
	6	57		361			633		
	8	78		2010		92	2577		118
	10	64		1040			1625		
	mean		75	1086.6		82	1431.28		97.80
	sed		6.32	293.80		6.43	361.57		11.60

(SEE FIGURE 2)

Further test data is set out below:
(See Figure 3)

Alanine Transferase Measurement in Ischemia Rats [Blood Stream];

RAT #	PREOP	POSTOP 0'	POSTOP 30'	POSTOP 60'	POP 0'%	POP 30' %	POP 60'%
1	67	229	1289	2030	342	1924	3030
2	73	279	1220	2120	382	1671	2904
3	76	890	1310	2020	1171	1724	2658
4	74	395	1070	1160	534	1446	1568
5	78	158	1080	1390	203	1385	1782
6	68	215	1170	2840	316	1721	4176
7	81	272	1140	1670	336	1407	2062
MEAN		348.29	1182.71	1890.00	469.05	1611.05	2597.10
SEM		101.99	38.78	225.04	132.59	82.69	364.79
8	98	478	1860	2940	488	1898	3000
9	83	190	2020	2600	229	2434	3133
10	89	436	2930	3400	490	3292	3820
11	105	590	1930	2600	562	1838	2476
12	88	277	2020	3400	315	2295	3864
13	91	220	2170	3710	242	2385	4077
14	98	343	1730	1940	350	1765	1980
MEAN	83.5	362.00	2094.29	2941.43	382.14	2272.47	3192.73
SEM		59.69	160.71	249.85	53.71	215.06	318.48

MEAN COMPARISON

	HA	CONTROL
postop 0'	348	362
postop 30'	1183	2094
postop 60'	1890	2941
postop 0'	469	382
postop 30'	1611	2272
postop 60'	2597	3193

This is the replacement sheet

Date: 21 AUG 1996

Example 4 HYALURONIC ACID (HA) ENHANCED ^{3}H-5-FLUOROURACIL UPTAKE IN THE MALPERFUSED RAT LIVER

Purpose: To assess the effect of HA on tritiated 5-Fluorouracil (^{3}H-5-Fu) uptake by acute and chronic malperfused rat liver tissue created in two surgical animal models.

1. Experiment model 1: Hepatic Ischemia/reperfusion.

Four groups of rats (A, B, C, D) were subjected to a 45 minute liver ischemia produced by clamping the hilus of the liver followed by a period of 60 minutes of reperfusion. Two sham (E, F) groups went through the same procedure except that the clamping time was not over 15 seconds and served as controls. All groups received intravenous (i.v.) ^{3}H-5-Fu (10 μCi/kg, Sigma) at the end of reperfusion period without (A, C, E) or with (B, D, F) i.v. HA (15mg/kg, Hyal). Groups C and D also underwent a "once-through" liver perfusion with normal saline to eliminate blood factor. Liver samples were collected ten minutes after the injection of ^{3}H-5-Fu and prepared for radioactivity counting.

2. Experiment model II: Liver-implanted tumour:

A single cell suspension containing half million rat Mammary Carcinoma cells per 0.1 ml was injected underneath the capsule of the left lobe of liver. This inoculation would grow within the liver tissue up to a single nodule, which would be with a diameter of 1 to 1.25 cm and weigh about 1 to 1.5 grams in about two weeks. Two groups of rats bearing two-week-old liver-implanted rat mammary carcinoma received i.v. ^{3}H-5-Fu alone or combined with i.v. HA Liver (LVR) and tumour (TMR) tissues were harvested ten minutes after and processed for radioactivity counting.

This is the replacement sheet
Date: 21 AUG 1996

Results: All the results were expressed as means of the counting plus and minus standard error. Statistics were done by using one way ANOVA to process the data.

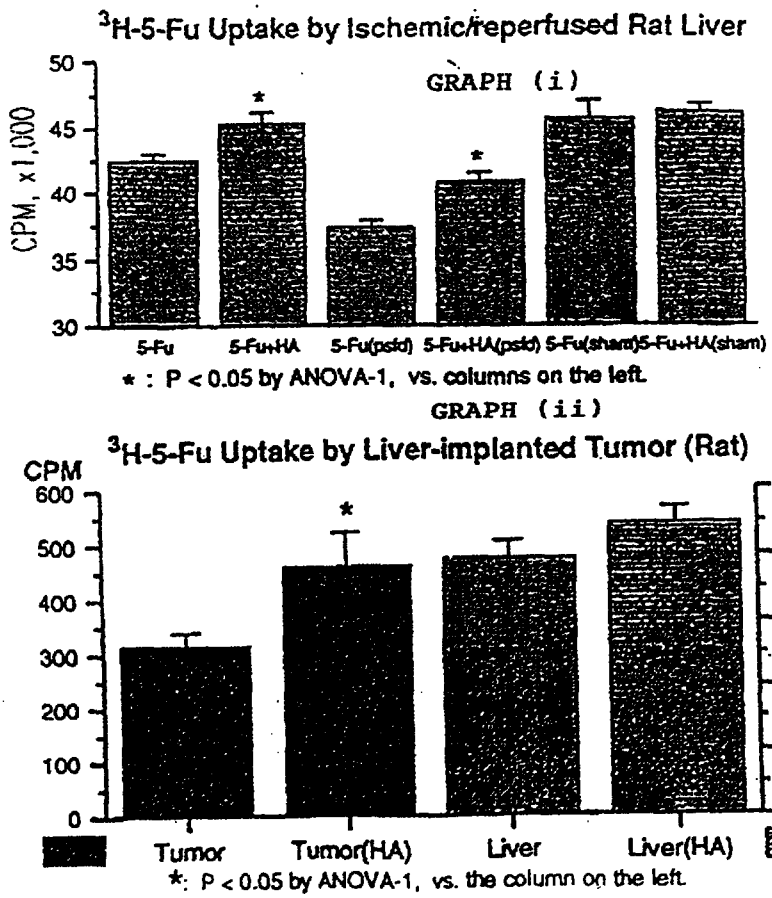
Table 1: *Hepatic ischemia/reperfusion model*

Group(n=)	A(9)	B(9)	C(9)	D(6)	E(8)	F(9)
meansCPM	42487	45392*	37372	40790*	45591	46261
SEM	±569	±839	±468	±665	±1328	±536

Table 2: *Liver-implanted tumour model*

Tissue(n=)	TMR(9)	TMR(HA)(9)	LVR(9)	LVR(HA)(9)
meanCPM	314	461*	1979	2237
SEM	±25	±61	±133	±122

In the results, * means P<0.05 by ANOVA-1, vs. untreated groups.
CPM=count per minute; SEM=standard error.



This is the replacement sheet

Date: 21 AUG 1996

It is apparent from the above graphs (i) and (ii) that the exogenous HA significantly enhanced the uptake or distribution of ^{3}H-5-Fu in the ischemic/reperfused liver tissue and liver-implanted tumour tissue.

Example 5 **HA Distribution in The Liver of Hepatic Ischemia/reperfusion Rats**

In our previous examples, we have confirmed that the exogenous HA can enhance the uptake or distribution of certain pharmaceutics. What we still do not know is the distribution of HA itself under the pathological situation. Therefore, we design this experiment to reveal the picture of HA distribution in a ischemic/reperfused rat model.

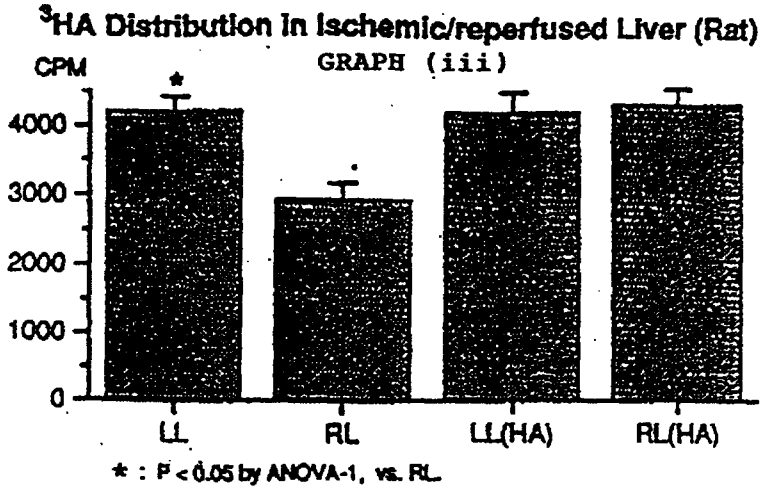
Animal: Fischer 344, male, 200 gm of body weight.

Two groups of rats were subjected to a 60 minute liver ischemia produced by clamping the left side of hilus of liver followed by period of 30 minutes reperfusion. Then all the animals received an injection of either exogenous HA (15 mg/kg) or same amount of normal saline through peripheral vein. Ten minutes later, tritium labeled HA (20 μCi/kg) was given intravenously. After another five minutes, pieces of tissue were harvested from right and left lobes of liver separately and processed for β counting.

As can be seen from graph (iii) below without the exogenous cold HA, the damaged side of the liver contained significantly higher counting compared with the right lobe. When the liver was preloaded with cold HA, however, no significant difference was shown in the counts of both sides.

This is the replacement sheet

Date: 21 AUG 1996



As many changes can be made to the preferred embodiments of the invention without departing from the scope of the invention; it is intended that all material herein be treated as illustrative of the invention and not in a limiting sense.

This is the replacement sheet

Date: 2 1 AUG 1996

CLAIMS

1. A pharmaceutical composition comprising an effective non-toxic amount of hyaluronic acid (HA) and or salts thereof and/or homologues, analogues, derivatives, complexes, esters, fragments and units of HA in association with a suitable diluent or pharmaceutically acceptable carrier for use in treating ischemia damage in tissue.

2. The pharmaceutical composition of claim 1 wherein the amount of hyaluronic acid is selected from hyaluronic acid and salts thereof.

3. The pharmaceutical composition of claim 2 for treating ischemia damage in tissue through reperfusion or the like.

4. The pharmaceutical composition of claim 2 for use in treating ischemia damage in internal organs.

5. The pharmaceutical composition of claim 2 for use in treating ischemia damage in the liver.

6. The pharmaceutical composition of claim 2 for use in treating ischemia damage in the kidneys.

7. The pharmaceutical composition of claim 2 for use in treating ischemia damage in the heart.

8. The pharmaceutical composition of claims 2 or 4 where said treatment comprises reperfusion.

This Sheet Has Been Replaced

This is the replacement sheet

Date: 21 AUG 1996

* C L M S *

9. The pharmaceutical composition of claims 5, 6 or 7 where said treatment comprises reperfusion.

10. The pharmaceutical composition of claim 2 for use in treating ischemia damage in tissue during transplantation.

11. The pharmaceutical composition of claim 2 for use in treating ischemia damage in tissue during transplantation of internal organs.

12. The pharmaceutical composition of claim 2 for use in treating ischemia damage in tissue during transplantation of the liver.

13. The pharmaceutical composition of claim 2 for use in treating ischemia damage in tissue during transplantation of the kidney or kidneys.

14. The pharmaceutical composition of claim 2 for use in treating ischemia damage in tissue during transplantation of the heart.

15. The pharmaceutical composition of claims 1-14 inclusive wherein the amount of hyaluronic acid or forms thereof is between about 300 mg to about 7 grams.

16. A formulation for reducing Alanine Aminotransferase enzyme production by a liver when damaged or is experiencing ischemia, said formulation comprising an effective non-toxic amount of hyaluronic acid and/or salts thereof in association with a suitable diluent or pharmaceutically acceptable carrier.

This Sheet Has Been Replaced

This is the replacement sheet

Date: 21 AUG 96

* C L M S *

17. The use of a pharmaceutical composition for use in treating ischemia damage in tissue, the use comprising administering an effective non-toxic amount of hyaluronic acid and/or salts thereof and/or homologues, analogues, derivatives, complexes, ester, fragments and units of hyaluronic acid for treating ischemia damage in tissue, in association with a suitable diluent or pharmaceutically acceptable carrier.

18. The use of a pharmaceutical composition for treating ischemia damage in tissue comprising an effective non-toxic amount of hyaluronic acid and/or salts thereof for treating ischemia damage in tissue in association with a suitable diluent or pharmaceutically acceptable carrier.

19. The use of claim 17 wherein the amount of the form of hyaluronic acid administered is between about 300 mg and about 7 grams/70 kg person per day.

20. The use of claim 18 wherein the amount of hyaluronic acid or salt thereof administered is between about 300 mg and about 7 grams/70 kg person per day.

21. The use of the pharmaceutical composition of claim 18 or 20 wherein the tissue is selected from the internal organs.

22. The use of the pharmaceutical composition of claim 18 or 20 wherein the tissue is the liver.

23. The use of the pharmaceutical composition of claim 18 or 20 wherein the tissue is the kidneys.

This Sheet Has Been Replaced

This is the replacement sheet

Date: 21 AUG 1996

* C L M S *

24. The use of the pharmaceutical composition of claim 18 or 20 wherein the tissue is the heart.

25. The use of the pharmaceutical composition of claim 18 or 20 wherein the composition is used for treating or preventing ischemia damage in tissue during transplantation.

26. The use of the pharmaceutical composition of claim 18 or 20 wherein the composition is used for treating or preventing ischemia damage in tissue during transplantation of internal organs.

27. The use of the pharmaceutical composition of claim 18 or 20 wherein the composition is used for treating or preventing ischemia damage in tissue during transplantation of the liver.

28. The use of the pharmaceutical composition of claim 18 or 20 wherein the composition is used for treating or preventing ischemia damage in tissue during transplantation of the kidney or kidneys.

29. The use of the pharmaceutical composition of claim 18 or 20 wherein the composition is used for treating or preventing ischemia damage in tissue during transplantation of the heart.

30. The use of a formulation for the medical treatment of reducing Alanine Aminotransferase enzyme production by a liver when damaged or experiencing ischemia comprising administering a formulation comprising an effective non-toxic amount of hyaluronic acid and/or salts thereof in association with a suitable diluent or pharmaceutically acceptable carrier to the liver.

This Sheet Has Been Replaced

This is the replacement sheet

Date: 21 AUG 1996

* C L M S *

31. The use of claim 30 wherein the amount of hyaluronic acid and/or salts thereof is from about 300 mg to about 7 grams/70 kg person per day.

32. The formulation of claim 16 wherein the amount of hyaluronic acid and/or salts thereof is from between about 300 mg to about 7 grams.

33. The pharmaceutical composition of claim 2 for use in treating ischemia damage in the lungs.

34. The use of the pharmaceutical composition of claim 18 or 20 wherein the tissue is the lungs.

35. The use of the pharmaceutical composition of claim 18 or 20 wherein the composition is used for treating or preventing ischemia damage in tissue during the transplantation of the lungs.

This Sheet Has Been Replaced

This is the replacement sheet

Date: 21 AUG 1996

ABSTRACT

THE USE OF HYALURONIC ACID TO REPAIR ISCHEMIA REPERFUSION DAMAGE.

A pharmaceutical composition comprising an effective non-toxic amount of hyaluronic acid (HA) and or salts thereof and/or homologues, analogues, derivatives, complexes, esters, fragments and units of HA in association with a suitable diluent or pharmaceutically acceptable carrier for use in treating ischemia damage in tissue.

(No appropriate figure)

This is the replacement sheet

Date: 21 AUG 1996

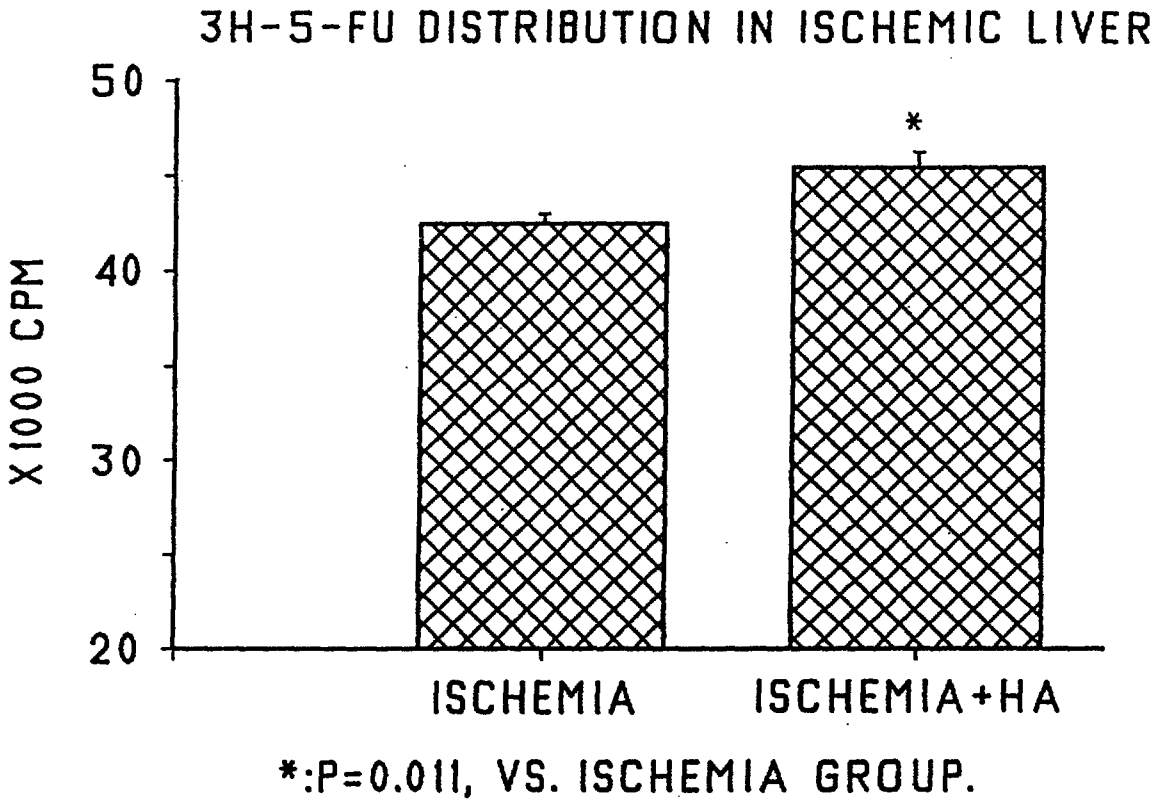


FIG.1.

This is the replacement sheet

Date: 21 AUG 1996

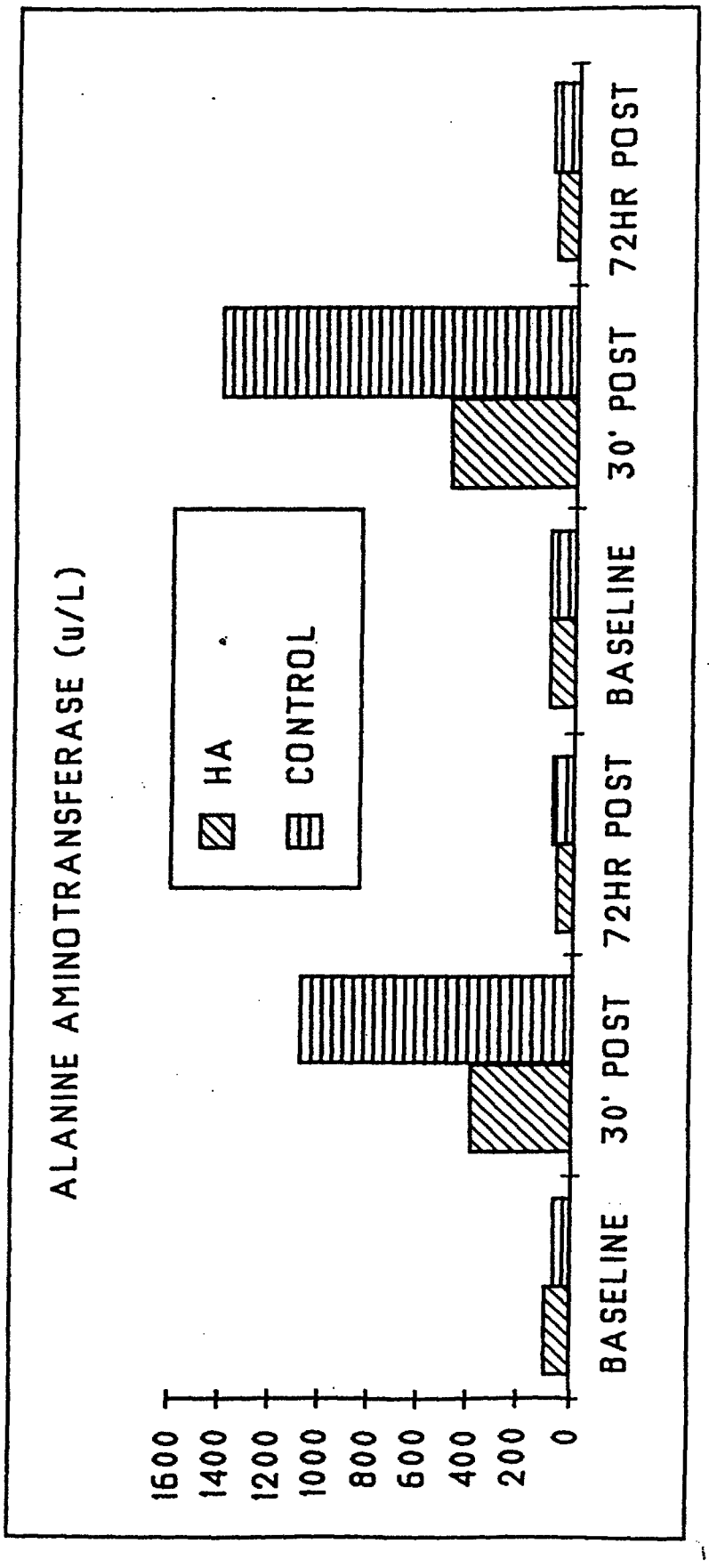


FIG.2.

This is the replacement sheet

Date: 21 AUG 1996

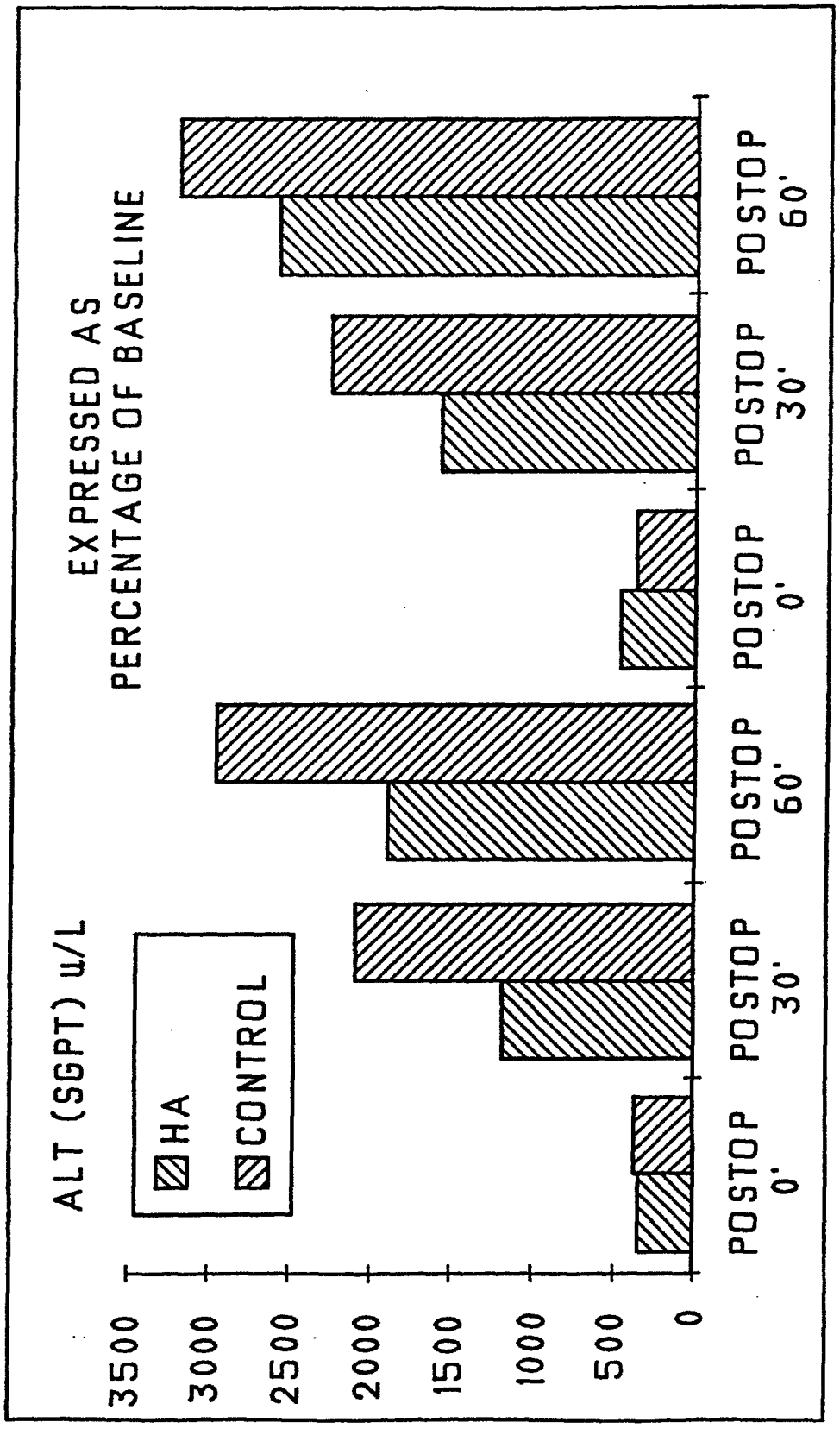


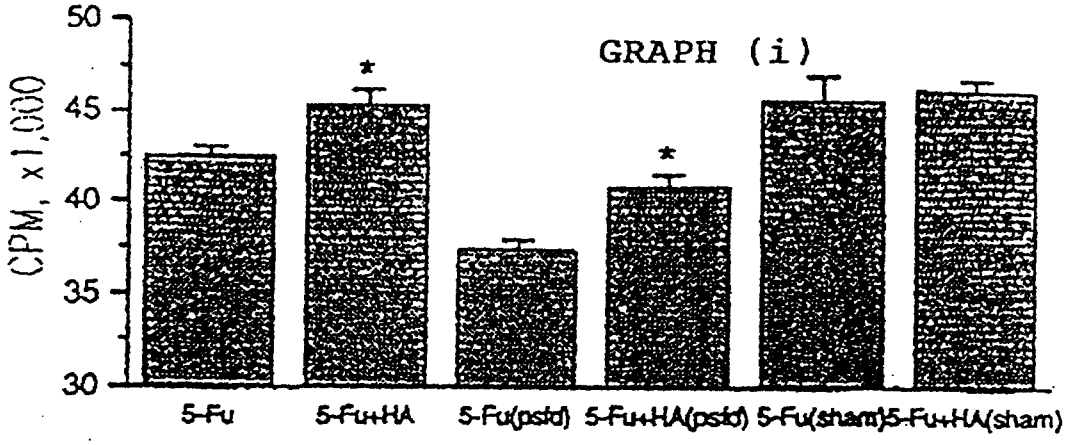
FIG.3.

This is the replacement sheet

Date: 21 AUG 1996

^{3}H-5-Fu Uptake by Ischemic/reperfused Rat Liver

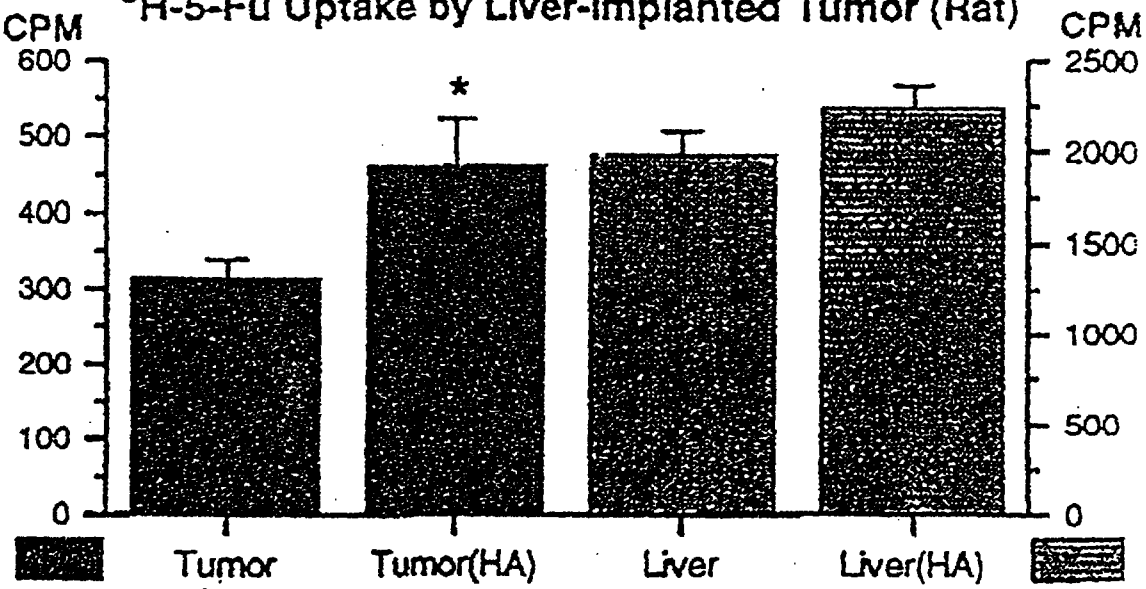
GRAPH (i)



* : P < 0.05 by ANOVA-1, vs. columns on the left.

GRAPH (ii)

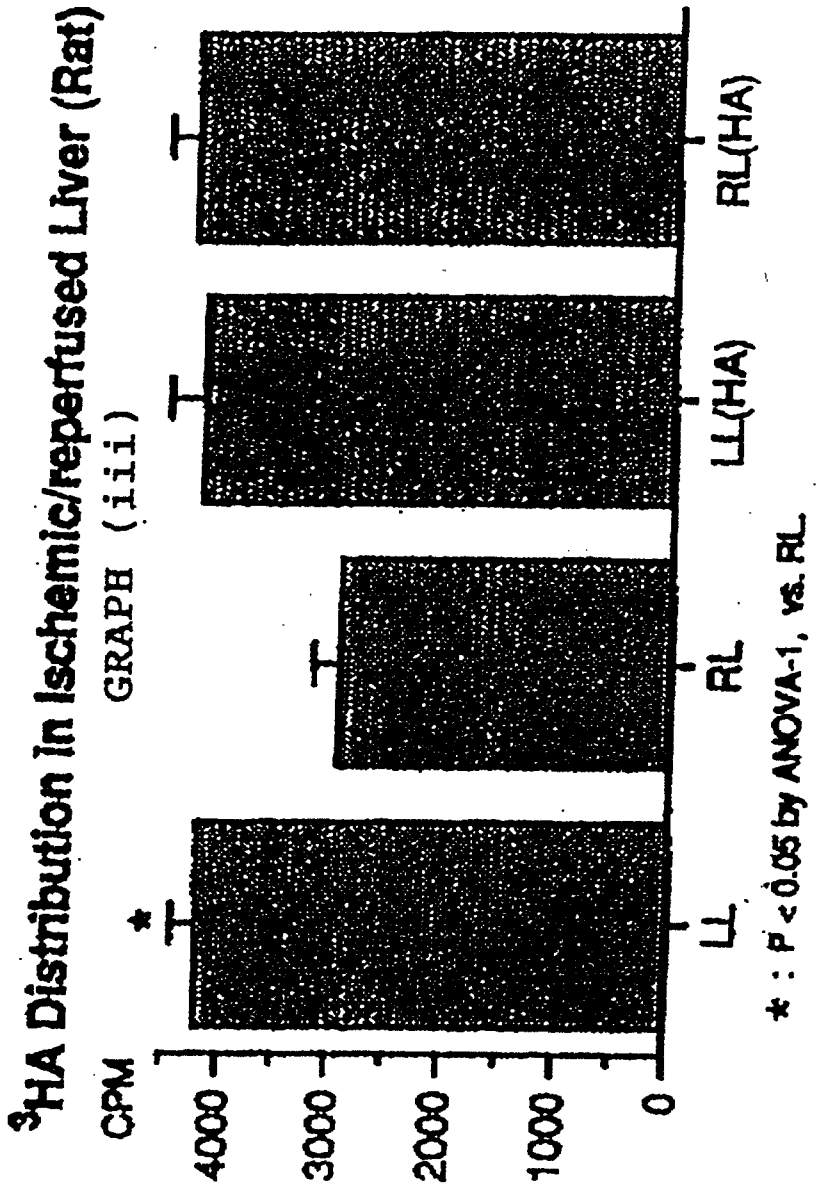
^{3}H-5-Fu Uptake by Liver-implanted Tumor (Rat)



*: P < 0.05 by ANOVA-1, vs. the column on the left.

This is the replacement sheet

Date: 21 AUG 1996



This is the replacement sheet

Date: 21 AUG 1996

960901-2 IPOS

REPLACEMENT SHEETS SG
☐ Description : paged ..... to paged ...
☑ Claim(s) : paged ..16.. to paged ..17..
☐ Drawing(s) : paged ..... to paged .....
☐ Abstract : paged ..... to paged .....

DATE OF RECEIPT .....3/2/2K.....

3/2/2K

Claims

1. A dosage amount of a pharmaceutical composition in a pharmaceutically acceptable form comprising an effective non-toxic amount of a form of hyaluronic acid selected from hyaluronic acid (HA) and salts thereof in association with a suitable diluent or pharmaceutically acceptable carrier for use in treating ischemia damage in tissue.

2. The dosage of claim 1 wherein the form of hyaluronic acid is sodium hyaluronate having a molecular weight of less than 750,000 daltons and the pharmaceutically acceptable form of the composition is for intravenous or injectible use.

3. The dosage of claim 2 for treating ischemia damage in tissue due to reperfusion.

4. The dosage of claim 2 for use in treating ischemia damage due to transplantation of internal organs.

5. The dosage of claim 2 for use in treating ischemia damage in the liver.

6. The dosage of claim 2 for use in treating ischemia damage in the kidneys.

7. The dosage of claim 2 for use in treating ischemia damage in the heart.

8. The dosage of claim 1, 2, 3, 4, 5, 6 or 7 wherein said ischemia damage is due to transplantation.

This is the replacement sheet
Date: 03 APR 2000
03 APR 2000

9. The pharmaceutical composition of claims 1-8 inclusive wherein the dosage amount of the form of hyaluronic acid is between about 300 mg to about 7 grams.

10. A dosage amount of a pharmaceutical composition in a pharmaceutically acceptable form for reducing Alanine Aminotransferase enzyme production by a liver in a person when damaged by, or is experiencing, ischemia, said composition comprising an effective non-toxic amount of a form of hyaluronic acid selected from hyaluronic acid and salts thereof in association with a suitable diluent or pharmaceutically acceptable carrier.

11. The dosage of claim 10 wherein the form of hyaluronic acid is sodium hyaluronate having a molecular weight less than 750,000 daltons.

12. The dosage of claim 11 wherein the pharmaceutically acceptable form of the composition is for intravenous or injectible use.

13. The dosage of claim 9, 10 or 11 wherein the amount of the form of hyaluronic acid is from about 300mg to about 7 grams.

14. The use of an effective non-toxic amount of a form of hyaluronic acid selected from hyaluronic acid and salts thereof in association with a suitable diluent or pharmaceutically acceptable carrier for the manufacture of a medicament for treating ischemia damage in tissue.

15. The use of claim 14 wherein the form of hyaluronic acid is sodium hyaluronate having a molecular weight of less than 750,000 daltons and the

pharmaceutically acceptable form of the composition is for intravenous or injectible use.

16. The use of claim 15 for treating ischemia damage in tissue due to reperfusion.

17. The use of claim 15 for treating ischemia damage due to transplantation of internal organs.

18. The use of claim 15 for treating ischemia damage in the liver.

19. The use of claim 15 for treating ischemia damage in the kidneys.

20. The use of claim 15 for treating ischemia damage in the heart.

21. The use of claim 14, 15, 16, 17, 18, 19 or 20 wherein said ischemia damage is due to transplantation.

22. The use of claims 14-21 inclusive wherein the dosage amount of the form of hyaluronic acid is between about 300 mg to about 7 grams.

23. The use of an effective non-toxic amount of hyaluronic acid and salts thereof in association with a suitable diluent or pharmaceutically acceptable carrier for manufacture of a medicament for reducing Alanine Aminotransferase enzyme production by a liver when damaged by, or experiencing ischemia.

This is the replacement sheet

Date: 23 APR 2000

* C L M S *

24. The use of claim 23 wherein the form of hyaluronic acid is sodium hyaluronate having a molecular weight less than 750,000 daltons.

25. The use of claim 23 wherein the pharmaceutically acceptable form of the composition is for intravenous or injectible use.

26. The use of claims 23, 24 or 25 wherein the amount of the form of hyaluronic acid is from about 300mg to about 7 grams.

This is the replacement sheet

Date: 03 APR 2000