Subtotal pancreatectomy in five different rat strains: Incidence and course of development of diabetes

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Summary. The incidence and course of development of diabetes was studied for 12 months after subtotal pancreatectomy in five strains of rats. Operations were performed on 5–7-week old-male animals weighing 100–140 g, and, subsequently, rats with fasting blood glucose levels >8.3 mmol/l were considered to be diabetic. In Füllinsdorf Albino rats, the proportion of diabetic animals gradually increased during the course of the experiment to a maximum of 83%. In Holtzman and Piebald rats, the highest incidence (58% and 28% respectively) was observed 2–3 months after surgery, after which partial remission of their diabetes occurred. Spontaneously hypertensive rats completely recovered from an initially mild diabetic state within 6 months of the operation. In Lewis rats, only a small number of animals (15%) became diabetic to-

wards the end of the experiment. The severity of diabetes also differed considerably between strains. The pancreatic insulin content in diabetic rats was 2%–7% and in operated non-diabetic rats 17%–26% of values in non-operated control animals of the same age and strain. However, in the operated non-diabetic rats, glucose tolerance and the insulin response to glucose were also impaired.

It is concluded that there are marked inter-strain differences in rats concerning the incidence and development of diabetes following subtotal pancreatectomy.

Key words: Subtotal pancreatectomy, rat, diabetes, fasting blood glucose, glucose tolerance, insulin secretion, pancreatic-insulin, regeneration.

Pancreatectomy is one of the standard procedures in experimental diabetes research. Development of diabetes, however, depends to a large extent on the animal species and the surgical techniques applied [1]. In contrast with dogs [2], total pancreatectomy is difficult to achieve in rats because of the diffuseness of the organ in this species. Furthermore, published data indicate possible differences in the susceptibility of various strains of rats to the development diabetes. For example, in male Wistar Albino rats, the incidence of diabetes was reported to be 90% 6 months after subtotal pancreatectomy [3] and 50% after 3 months [4], while in another, not exactly defined strain (hooded rats), all animals became diabetic within 8 days of the operation [5]. This apparent variation led us to investigate the incidence and the course of development of diabetes during 12 months after subtotal pancreatectomy in five strains of rats available to us from our local breeding station.

Materials and methods

Animals

Male SPF rats (aged 5–7 weeks, 100–140 g body weight) of the following strains were obtained from the Institut für Biologisch-Medizi-

nische Forschung, Füllinsdorf, Switzerland: Füllinsdorf-Albino (Wistar derived), spontaneously hypertensive rats (Okamoto [6]), Lewis, Holtzman (Sprague Dawley derived) and Piebald (hooded). Approximately 1 week after their transfer to the local animal room (23 °C, 50%–60% relative humidity), the rats were fasted overnight and then anaesthetized with a combination of ketamine-HCl (90 mg/kg, intraperitoneally) and Valium (5 mg/kg, intraperitoneally). Pancreatectomy was performed according to Foglia [7] on a series of 40–50 animals of the same strain per day. By this procedure, all pancreatic tissue was removed, except for the part between the bile duct and duodenum, which remained untouched. Subsequently, 40–50 animals of the other strains were pancreatectomized by the same person, one strain of rats per day.

Methods

Fasting blood glucose was determined 7 h after withdrawal of food from the animals, which had been pre-starved for 18 h and then fed for 1 h. Animals that had blood glucose levels >8.3 mmol/l were considered to be diabetic. Glucose tolerance and insulinaemia were measured after an oral glucose load (10 ml/kg of a glucose solution containing 0.32 g glucose/ml H₂O) in unanaesthetized rats pre-starved for 24 h. Blood was taken from the tip of the tail at 0, 30 and 60 min and collected in chilled heparinized tubes. Plasma was prepared by centrifugation at 5600 g for 5 min and stored at -20 °C until assay.

After decapitation, pancreatic tissue was removed, dissected free of fat, weighed and stored at -20 °C. Pancreatic insulin was extracted with an acid ethanol solution (750 ml ethanol, 15 ml concentrated HCl (approximately 37%), 235 ml bidistilled H₂O).

Table 1. Pancreatic tissue weight and insulin content in five rat strains after subtotal pancreatectomy and in age-matched non-operated control animals (experiment 1)

Rat strains	Body weight (g)	Pancreatic wet weight (mg/100 g body weight)	Pancreatic insulin (mU/100 g body weight)
<i>After pancreatectomy</i>			
Füllinsdorf Albino (n=10)	97 ± 2	33 ± 2	68 ± 8
Spontaneously hypertensive (n=10)	90 ± 2	24 ± 2 ^a	94 ± 16
Lewis (n=10)	81 ± 1	36 ± 1	102 ± 15
Holtzman (n=8)	128 ± 10	37 ± 2	70 ± 10
Piebald (n=10)	96 ± 2	31 ± 2	73 ± 9
<i>Non-operated control rats</i>			
Füllinsdorf Albino (n=10)	98 ± 2	444 ± 16	922 ± 54
Spontaneously hypertensive (n=10)	92 ± 2	370 ± 14	837 ± 33
Lewis (n=10)	76 ± 1	475 ± 15	1185 ± 60
Holtzman (n=8)	133 ± 10	463 ± 2	544 ± 44
Piebald (n=10)	96 ± 2	371 ± 14	628 ± 22

Results expressed as mean ± SEM; ^a $p < 0.01$ compared with Füllinsdorf Albino, Lewis, Holtzman, Piebald strain rats (t-test)

Insulin was measured in plasma and neutralized pancreatic extracts using a double-antibody radioimmunoassay (Amersham International, Bucks, UK) with human insulin as a standard. Glucose was determined by a conventional enzymatic method using the Glucoquant kit (Boehringer No. 263826, Mannheim, FRG)

Experimental protocols

In a control experiment (experiment 1), the results of the operation were tested by determining the amount of pancreatic tissue remaining immediately after the operation, and its insulin content. For comparison, all pancreatic tissue was removed and dissected free from surrounding tissue in groups of age-matched control rats of the same strain.

In experiment 2, groups of operated animals and non-operated controls of each strain were maintained for a total of 12 months after surgery. Food and drinking water were withheld from these animals for 24 h after the operation. On the second post-operative day, the animals were provided with drinking water and a normal chow diet (Nafag No. 850: Nafag, Gossau, Switzerland) restricted to 7 g per animal per day. From then on, free access to food and drinking water was allowed.

Fasting blood glucose was determined periodically up to 11 months after surgery in all operated and non-operated control animals; food intake and body weight gain were also recorded. In some randomly selected animals of each group, a glucose tolerance and insulin secretion test was performed 11.5 months after subtotal pancreatectomy. In the same animals, pancreatic wet weight and insulin content were determined 2 weeks later.

Statistical analysis

Results are presented as mean ± SEM. Statistical differences were assessed using the two-tailed Student's t-test for non-paired values with a probability for significance of < 0.05 .

Results

Pancreatic tissue and insulin content remaining immediately after surgery

The amount of pancreatic tissue remaining after surgery was similar in four of the strains of rats studied (experiment 1, Table 1). In the spontaneously hypertensive rats only was the remaining tissue significantly less. The residual pancreas represented 6.5%–8.4% of the tissue dissected from age-matched unoperated controls. Total residual pancreatic insulin amounted to 7.4%–12.9% of control values with no significant differences between strains.

Mortality

In experiment 2, 25%–28% of the operated rats of four strains died within the first 2 weeks after surgery (Table 2). Only with Lewis rats, was the loss of animals smaller (9%). Additional mortality during the remainder of the experiment was 14%, 4%, 8% and 5% in Füllinsdorf Albino, spontaneously hypertensive, Holtzman and Piebald rats, respectively, with no further deaths in the Lewis strain rats.

Incidence of diabetes

Using fasting blood glucose as a criterion, there was a striking difference in the incidence of diabetes between the various rat strains. Not only did the maximum percentage of diabetic animals vary during the 11 months of observation from 15 (Lewis rates) to 83 (Füllinsdorf Albino rats), but the time of onset of diabetes also varied. Thus, in spontaneously hypertensive, Holtzman and Piebald rats, the maximum percentage of animals becoming diabetic was seen within 1–3 months after surgery and declined thereafter, whereas there was a continuous increase in the number of animals becoming diabetic among Füllinsdorf Albino rats during the experiment. Lewis rats appear to be exceptionally resistant to the development of diabetes after subtotal pancreatectomy. It was only towards the end of the experiment that the number of diabetic animals increased slightly (Table 2).

Pancreatic tissue and insulin content 12 months after subtotal pancreatectomy

The amount of pancreatic tissue recovered from the operated animals was similar in diabetic and non-diabetic animals of the same strain. Expressed as a percentage of the pancreatic tissue obtained from non-operated control rats of the same age and strain, the amount of tissue isolated from operated animals was remarkably constant in all strains tested. Compared with the percentage of pancreatic tissue recovered immediately after the operation (Table 1), the higher percentage recovered after

Table 2. Time course of survival and development of diabetes in five strains of rats after subtotal pancreatectomy (experiment 2)

Rat strains	Number of operated animals	Months after pancreatectomy											
		0.5	1	2	3	4.5	6	8	10	11	12		
Füllinsdorf Albino	51	Surviving	(no.)	37	37	36	36	35	33	32	31	30	30
			(%)	73	73	71	71	69	65	63	61	59	59
		Diabetic	(no.)	2	10	13	19	19	20	22	24	25	
		% of surviving animals		5	27	36	53	54	61	69	77	83	
Spontaneously hypertensive	50	Surviving	(no.)	36	36	36	36	36	36	36	36	36	34
			(%)	72	72	72	72	72	72	72	72	72	68
		Diabetic	(no.)	4	6	4	1	0	0	0	0	0	
		% of surviving animals		11	17	11	3	0	0	0	0	0	
Lewis	44	Surviving	(no.)	40	40	40	40	40	40	40	40	40	40
			(%)	91	91	91	91	91	91	91	91	91	91
		Diabetic	(no.)	1	1	1	1	1	2	1	3	6	
		% of surviving animals		3	3	3	3	3	5	3	8	15	
Holtzman	50	Surviving	(no.)	37	37	36	36	35	35	35	35	34	33
			(%)	74	74	72	72	70	70	70	70	68	66
		Diabetic	(no.)	13	19	21	19	13	16	11	11	7	
		% of surviving animals		35	51	58	53	37	46	31	31	21	
Piebald	44	Surviving	(no.)	33	33	32	32	32	32	32	32	31	31
			(%)	75	75	73	73	73	73	73	73	71	71
		Diabetic	(no.)	2	6	8	9	6	10	3	5	4	
		% of surviving animals		6	18	25	28	19	31	9	16	13	

Table 3. Pancreatic tissue weight and insulin content 12 months after subtotal pancreatectomy in five rat strains compared with age-matched non-operated control animals (experiment 2)

Rat strains		Body weight (g)	Pancreatic wet weight		Pancreatic insulin			
			(mg/100 g body weight)	% of control rats	Total (mU)	% of control rats	mU/100 g body weight	% of control rats
Füllinsdorf Albino	Controls (n=8)	(a) 479 ± 18	210 ± 10		2060 ± 68		432 ± 12	
	Operated: non-diabetic (n=4)	(b) 421 ± 12	72 ± 9	34	409 ± 85	20	97 ± 20	22
	Operated: diabetic (n=9)	(c) 287 ± 25	99 ± 11	47	25 ± 1	1	9 ± 1	2
	<i>p</i>	a:b NS	<0.001		<0.001		<0.001	
		b:c <0.01	NS		<0.001		<0.001	
Spontaneously hypertensive	Controls (n=8)	(a) 445 ± 6	219 ± 9		2441 ± 168		547 ± 35	
	Operated: non-diabetic (n=16)	(b) 426 ± 8	71 ± 8	32	577 ± 70	24	138 ± 16	25
	<i>p</i>	a:b NS	<0.001		<0.001		<0.001	
		b:c						
Lewis	Controls (n=8)	(a) 531 ± 23	193 ± 8		2628 ± 109		500 ± 25	
	Operated: non-diabetic (n=7)	(b) 457 ± 6	61 ± 4	32	491 ± 96	19	107 ± 21	21
	Operated: diabetic (n=5)	(c) 441 ± 28	68 ± 6	35	^a 93 ± 12	4	21 ± 3	4
	<i>p</i>	a:b <0.05	<0.001		<0.001		<0.001	
		b:c NS	NS		<0.01		<0.01	
Holtzman	Controls (n=8)	(a) 526 ± 16	274 ± 13		2415 ± 152		462 ± 31	
	Operated: non-diabetic (n=8)	(b) 551 ± 14	74 ± 7	27	438 ± 82	18	80 ± 15	17
	Operated: diabetic (n=6)	(c) 440 ± 12	107 ± 5	39	^a 51 ± 14	2	12 ± 3	3
	<i>p</i>	a:b NS	<0.001		<0.001		<0.001	
		b:c <0.001	NS		<0.01		<0.01	
Piebald	Controls (n=8)	(a) 553 ± 17	157 ± 6		4087 ± 212		764 ± 21	
	Operated: non-diabetic (n=8)	(b) 493 ± 26	45 ± 2	29	974 ± 113	24	200 ± 24	26
	Operated: diabetic (n=3)	(c) 340 ± 23	69 ± 13	44	173 ± 9	4	51 ± 4	7
	<i>p</i>	a:b NS	<0.001		<0.001		<0.001	
		b:c <0.01	<0.05		<0.01		<0.01	

Results expressed as mean ± SEM

Table 4. Fasting blood glucose in control and operated rats of five strains at various times after subtotal pancreatectomy (experiment 2)

Rat strains			Fasting blood glucose: months after pancreatectomy (mmol/l)									
			1		3		5.5		7.5		11	
Füllinsdorf Albino												
Controls	(a)		5.6 ± 0.2	(11)	5.3 ± 0.1	(11)	5.3 ± 0.1	(10)	4.9 ± 0.1	(10)	6.0 ± 0.1	(10)
Operated: non-diabetic	(b)		6.2 ± 0.2	(27)	6.4 ± 0.2	(17)	6.4 ± 0.2	(13)	5.2 ± 0.1	(10)	6.4 ± 0.4	(5)
Operated: diabetic	(c)		14.1 ± 1.1	(10)	16.8 ± 0.8	(19)	17.7 ± 0.7	(20)	17.0 ± 0.7	(22)	19.0 ± 0.9	(25)
	<i>p</i>	a : b	<0.05		<0.001		<0.001		<0.05		NS	
		b : c	<0.001		<0.001		<0.001		<0.001		<0.001	
Spontaneously hypertensive												
Controls	(a)		5.8 ± 0.3	(12)	5.1 ± 0.1	(12)	5.3 ± 0.1	(12)	4.9 ± 0.1	(12)	6.2 ± 0.1	(12)
Operated: non-diabetic	(b)		6.3 ± 0.2	(30)	5.9 ± 0.1	(35)	6.1 ± 0.1	(36)	5.6 ± 0.1	(36)	6.6 ± 0.1	(34)
Operated: diabetic	(c)		13.0 ± 1.5	(6)	12.2	(1)						
	<i>p</i>	a : b	NS		<0.001		<0.001		<0.001		<0.05	
		b : c	<0.001									
Lewis												
Controls	(a)		5.5 ± 0.2	(8)	4.9 ± 0.1	(8)	5.2 ± 0.1	(8)	4.9 ± 0.2	(8)	5.2 ± 0.1	(8)
Operated: non-diabetic	(b)		5.5 ± 0.1	(39)	5.4 ± 0.1	(39)	5.8 ± 0.1	(38)	5.6 ± 0.1	(39)	6.0 ± 0.1	(34)
Operated: diabetic	(c)		8.6	(1)	13.6	(1)	10.5 ± 1.9	(2)	10.1	(1)	9.4 ± 0.2	(6)
	<i>p</i>	a : b	NS		<0.01		<0.01		<0.05		<0.01	
		b : c	—		—		<0.001		—		<0.001	
Holtzman												
Controls	(a)		5.8 ± 0.1	(11)	5.5 ± 0.1	(11)	5.5 ± 0.2	(11)	5.6 ± 0.1	(11)	5.4 ± 0.1	(11)
Operated: non-diabetic	(b)		6.7 ± 0.2	(18)	6.5 ± 0.2	(17)	6.8 ± 0.2	(19)	6.4 ± 0.2	(22)	6.1 ± 0.2	(27)
Operated: diabetic	(c)		16.7 ± 1.1	(19)	18.9 ± 0.8	(19)	17.8 ± 1.0	(16)	14.0 ± 0.9	(13)	13.0 ± 1.6	(7)
	<i>p</i>	a : b	<0.01		<0.01		<0.001		<0.001		<0.05	
		b : c	<0.001		<0.001		<0.001		<0.001		<0.001	
Piebald												
Controls	(a)		5.3 ± 0.2	(12)	5.4 ± 0.1	(12)	5.7 ± 0.1	(12)	5.1 ± 0.1	(12)	5.1 ± 0.1	(12)
Operated: non-diabetic	(b)		5.6 ± 0.2	(27)	6.2 ± 0.1	(23)	6.4 ± 0.1	(22)	5.6 ± 0.2	(29)	5.7 ± 0.1	(27)
Operated: diabetic	(c)		14.3 ± 1.2	(6)	15.6 ± 1.6	(9)	12.8 ± 1.0	(10)	14.2 ± 2.3	(3)	11.2 ± 1.5	(4)
	<i>p</i>	a : b	NS		<0.001		<0.001		<0.05		<0.01	
		b : c	<0.001		<0.001		<0.001		<0.001		<0.001	

Results expressed as mean ± SEM with number of animals in parentheses

12 months clearly indicates growth of the tissue remaining after surgery (Table 3).

However, there was a marked difference in total pancreatic insulin between diabetic and non-diabetic animals. A pancreatic insulin content of 17%–26% of control values was apparently sufficient to maintain fasting blood glucose <8.3 mmol/l in all strains. Diabetic rats exhibited markedly lower amounts of pancreatic insulin (2%–7%).

Fasting blood glucose, glucose tolerance and insulin secretion

Among the diabetic animals, the highest values of fasting blood glucose determined at various times after surgery were recorded in Füllinsdorf Albino and Holtzman strain rats followed by Piebald and spontaneously hypertensive rats. The lowest levels were observed in diabetic Lewis rats. In operated non-diabetic animals, fasting blood glucose was higher than in control rats, and on all but four occasions this difference was significant (Table 4). Towards the end of the second experiment, glucose tolerance was measured in some randomly selected animals of each strain. Compared with diabetic

animals of the other strains, the more marked deterioration of glucose metabolism in Füllinsdorf Albino and Holtzman rats was also reflected in the impairment of glucose tolerance. The insulin response to glucose was small or absent (Table 5). In animals considered to be non-diabetic, according to their fasting blood glucose value, glucose tolerance was also impaired and their insulin response was between that of unoperated controls and diabetic animals of the same strain. In Lewis rats, the insulin response to glucose was almost absent in both diabetic and non-diabetic animals.

Food intake and body weight

As expected [8], diabetic animals showed impaired weight gain (Table 3), although food intake was markedly elevated compared with control animals.

Discussion

Development of diabetes after pancreatectomy is known to vary between species and probably between different strains of the same species. To our knowledge

Table 5. Blood glucose and insulin response to an oral glucose load (3.2 g/kg body weight) after 24 h of food deprivation in five strains of control rats and in rats subjected to subtotal pancreatectomy 12 months before (experiment 2)

Rat strains		Blood glucose (mmol/l) at times (min)			Plasma insulin (mU/l) at times (min)		
		0	30	60	0	30	60
Füllinsdorf Albino							
Controls (n=8)	(a)	4.6 ± 0.2	7.6 ± 0.3	7.8 ± 0.2	19.6 ± 2.4	98.4 ± 10.0	63.5 ± 6.9
Operated: non diabetic (n=4)	(b)	4.9 ± 0.2	11.0 ± 0.4	12.7 ± 0.8	18.3 ± 2.2	64.9 ± 16.8	59.5 ± 17.2
Operated: diabetic (n=9)	(c)	16.4 ± 2.2	27.6 ± 2.8	28.1 ± 2.1	17.6 ± 1.7	16.8 ± 1.9	11.8 ± 1.6
<i>p</i>	a:b	NS	<0.001	<0.001	NS	NS	NS
	b:c	<0.01	<0.01	<0.001	NS	<0.01	<0.01
Spontaneously hypertensive							
Controls (n=8)	(a)	4.8 ± 0.1	10.6 ± 0.6	12.4 ± 0.7	22.4 ± 2.0	105.8 ± 17.7	156.1 ± 19.7
Operated: non diabetic (n=16)	(b)	4.6 ± 0.1	12.4 ± 0.3	15.8 ± 0.8	14.9 ± 1.8	69.5 ± 7.3	88.7 ± 6.0
<i>p</i>	a:b	NS	<0.01	<0.05	<0.05	<0.05	<0.001
Lewis							
Controls (n=8)	(a)	4.5 ± 0.2	7.2 ± 0.2	7.9 ± 0.3	24.0 ± 4.4	93.5 ± 19.4	94.1 ± 22.8
Operated: non diabetic (n=7)	(b)	4.7 ± 0.1	12.4 ± 0.8	18.0 ± 0.8	16.9 ± 1.2	17.8 ± 3.7	24.0 ± 4.5
Operated: diabetic (n=5)	(c)	5.4 ± 0.6	16.2 ± 0.7	19.4 ± 2.2	21.4 ± 3.2	18.9 ± 1.8	19.0 ± 1.9
<i>p</i>	a:b	NS	<0.001	<0.001	NS	<0.01	<0.05
	b:c	NS	<0.01	NS	NS	NS	NS
Holtzman							
Controls (n=8)	(a)	4.5 ± 0.2	7.3 ± 0.3	7.4 ± 0.2	13.0 ± 1.9	76.2 ± 14.2	44.4 ± 6.3
Operated: non diabetic (n=8)	(b)	4.7 ± 0.1	10.2 ± 0.7	13.4 ± 0.8	12.1 ± 2.3	32.5 ± 9.0	26.2 ± 7.0
Operated: diabetic (n=6)	(c)	8.2 ± 2.2	23.1 ± 2.4	26.9 ± 1.9	15.2 ± 2.4	19.2 ± 2.9	12.3 ± 3.5
<i>p</i>	a:b	NS	<0.01	<0.001	NS	<0.01	NS
	b:d	<0.05	<0.001	<0.001	NS	NS	NS
Piebald							
Controls (n=8)	(a)	4.8 ± 0.1	9.2 ± 0.3	8.9 ± 0.5	33.2 ± 6.0	140.3 ± 17.2	66.9 ± 16.9
Operated: non diabetic (n=8)	(b)	4.7 ± 0.1	10.8 ± 0.6	12.3 ± 1	21.7 ± 1.6	81.5 ± 12.1	45.9 ± 8.6
Operated: diabetic (n=3)	(c)	5.4 ± 0.3	19.5 ± 1.0	25.0 ± 0.5	18.8 ± 2.6	28.9 ± 4.2	29.3 ± 7.8
<i>p</i>	a:b	NS	<0.05	<0.01	NS	<0.05	NS
	b:c	<0.05	<0.001	<0.001	NS	<0.05	NS

Results expressed as mean ± SEM

this is the first comparative study examining the effects of subtotal pancreatectomy in rats of different strains. Only male rats aged 5–7 week were used in order to exclude sex [9] and age differences. With the surgical technique applied, a similarly small amount of pancreatic insulin remained in all five strains of rats. The loss of 25% of animals within the first 2 weeks after surgery is in accordance with the experience of others [10]. The constant nature of the death rate within this period, at least in four strains, and the lack of a correlation with the percentage of diabetic animals 2 weeks after the operation, suggests that surgical stress may be the predominant cause of death. Subsequent mortality was small and approximately the same in both operated diabetic and non-diabetic animals. The surprisingly low incidence of diabetes 2 weeks after operation in four of the five strains indicates a very low insulin requirement for maintenance of normal fasting blood glucose levels in young rats. The reason for the variable pattern of incidence, severity and duration of diabetes between 1 and 12 months of observation is not known. Compared with non-operated age-matched control rats, the amount of pancreatic insulin remaining immediately after surgery was between 7.4% and 12.9% in the animals of different strains. Twelve months later, this percentage was be-

tween 17% and 26% in operated non-diabetic rats and 2%–7% in diabetic rats. These data suggest a proliferation of insulin-producing tissue in the non-diabetic rats, whereas further degeneration of the remaining islets may be assumed in the diabetic animals. Partial recovery from diabetes in rats after pancreatectomy or alloxan injection has been described previously [11]. It has also been suggested that the capacity of β cells to proliferate could be genetically determined and that diabetes may become manifest if β cell proliferation cannot meet an increased insulin demand [12]. Replication of differentiated β cells is well established, and various factors are believed to have an influence on their replication in vivo [4, 12, 13]. Trimble et al. [14] have described different functions of islets from either the dorsal or ventral parts of the rat pancreas. In our experiments, the remaining pancreatic tissue belonged to the dorsal pancreatic area (upper head) which is assumed to be the glucagon-rich (pancreatic polypeptide-poor) part [15]. At present, it is unknown whether there are strain differences in pancreatic islet distribution, which hypothetically could modulate the diabetic response to subtotal pancreatectomy.

In conclusion: (1) the percentage of diabetic rats was surprisingly small 2 weeks after subtotal pancrea-

tectomy and (2) the incidence, severity of and recovery from diabetes in rats after subtotal pancreatectomy was strain-dependent.

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