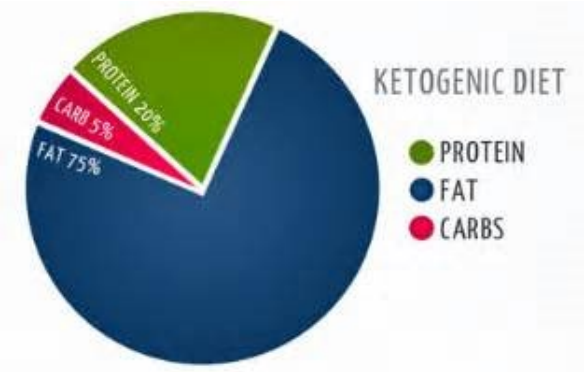
生酮治疗新进展

生酮饮食（Ketogenic diet，KD）：特殊设计产生酮体的饮食。

当摄入葡萄糖<100g/d或<2g/kg·d时，机体可动员脂肪而产生酮体。

核心：低碳水化合物、高油脂及适量蛋白质。



生酮饮食的分类

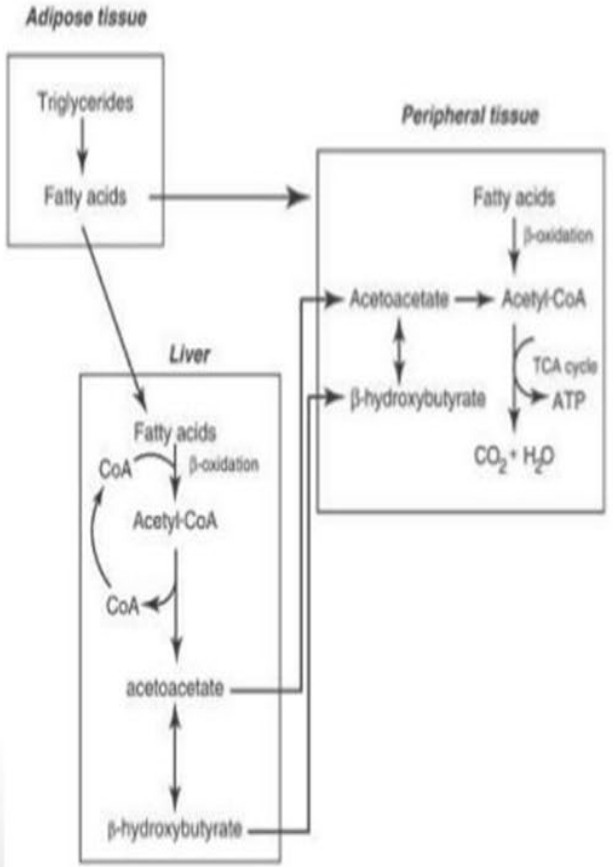
	经典KD	MCTD	MAD	LGID
脂肪，g（% kcal）	100（90%）	78（70%）	70（70%）	60（45%）
蛋白质，g（% kcal）	17（7%）	25（10%）	60（25%）	40（28%）
碳水化合物，g（% kcal）	8（3%）	50（20%）	10（5%）	40（27%）

- 注：KD：ketogenic diet,生酮饮食；MCTD：medium-chain triglyceride diet，中链脂肪饮食；MAD：modified Atkins diet，改良Atkins饮食；LGID：low glycemic index diet，低血糖指数饮食。

鲁运新,石汉平. 肿瘤代谢与营养电子杂志,2015,2(1),61-66.

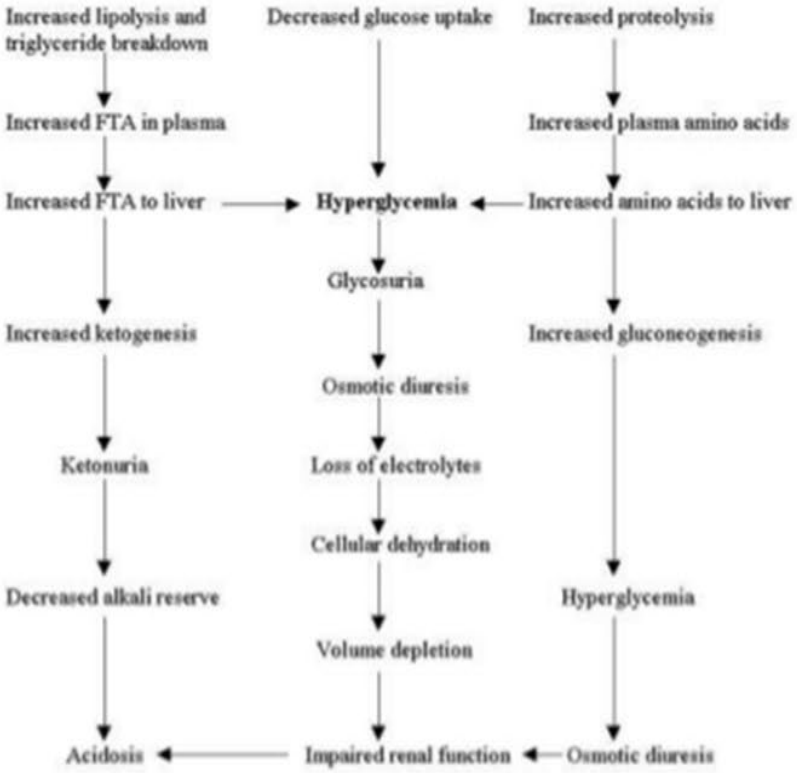
营养性酮症和糖尿病酮症

Starvation induced ketosis



- In early stages of starvation , heart and skeletal muscle consume primarily ketone bodies to preserve glucose for use by the brain.
- After several weeks of starvation, ketone bodies become the major fuel of the brain.

Diabetic Keto- acidosis



Diabetic Ketoacidosis may be diagnosed when the combination of **hyperglycemia (high blood sugars), ketones on urinalysis and acidosis are demonstrated.**

Blood levels during a normal diet, ketogenic diet and diabetic ketoacidosis

Blood levels	*Normal diet*	*Ketogenic diet*	*Diabetic ketoacidosis*
Glucose (mg/dl)	80–120	65–80	>300
Insulin (μU/l)	6–23	6.6–9.4	≅ 0
KB conc (mM/l)	0.1	7/8	>25
pH	7.4	7.4	<7.3

Skin Pharmacol Physiol. 2012;25:111–117.

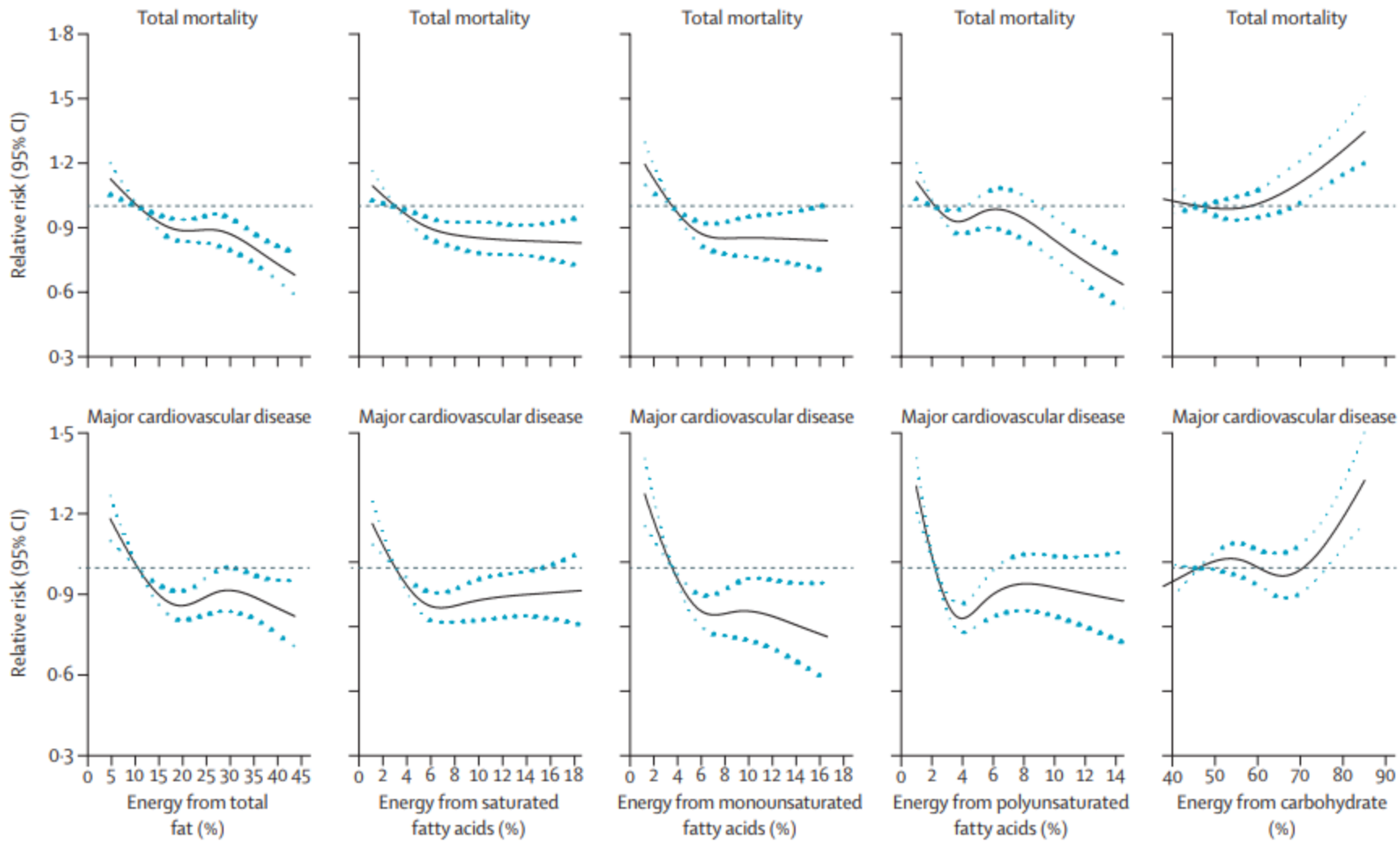
体重管理（strong evidence）

- 抑制食欲。1）CCK的直接作用 2）脂肪和蛋白质的饱腹感
- 降低血胰岛素水平——减少脂肪合成，增加脂肪动员
- 糖异生作用，增加400Kcal/d左右的能量消耗。
- 降低净息呼吸商。
- 酮体从尿、呼吸道、皮肤的外排。

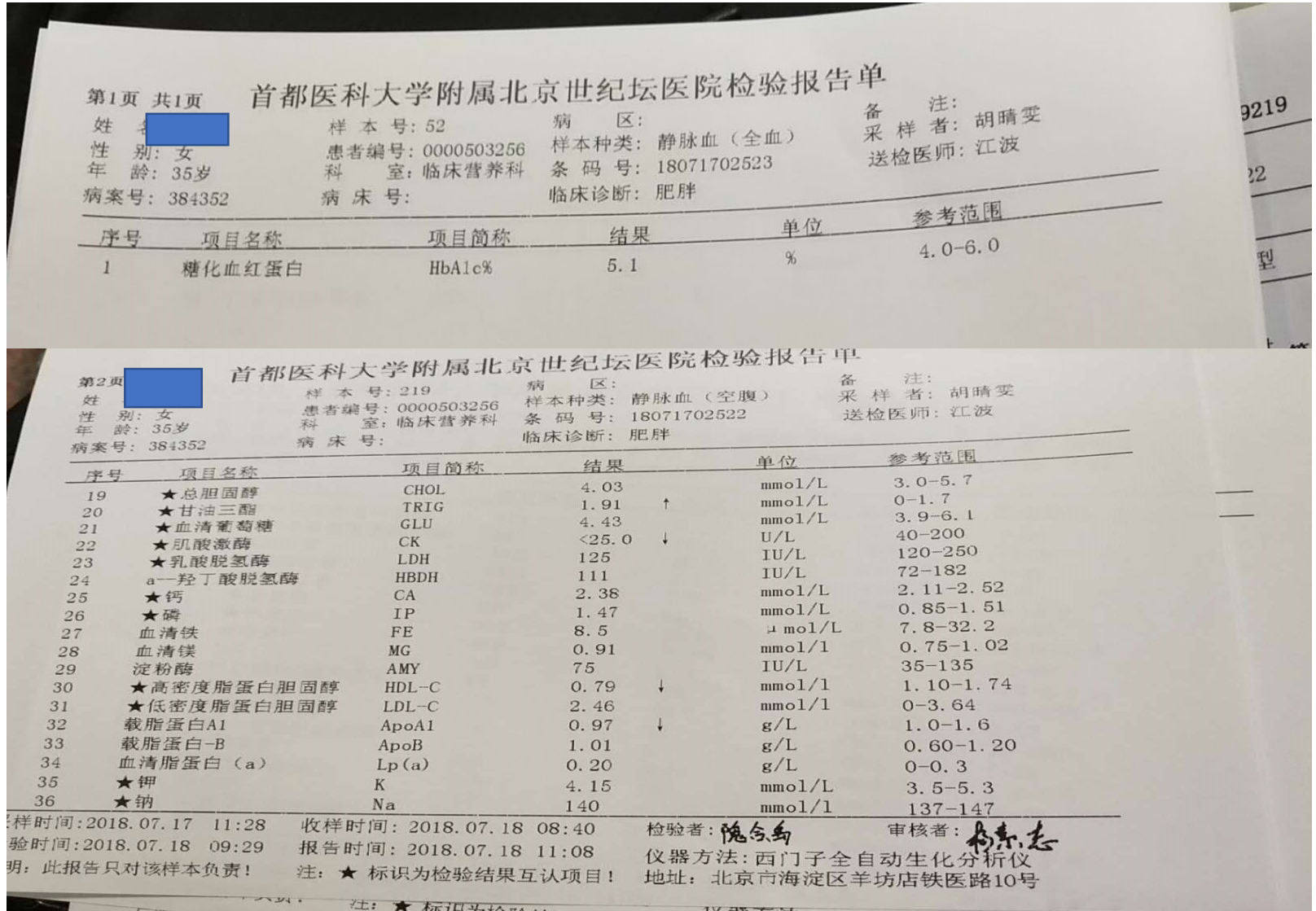
Outpatient LCKD RCTs: Weight Loss and Serum Lipids

		Low Fat				Low Carbohydrate			
Ref	Duration	Weight	LDL	Trig	HDL	Weight	LDL	Trig	HDL
Sondike n=30	3 mo	-4.1kg	-17%*	-6%	+2%	-9.9kg*	+4%	-48%*	+4%
Brehm n=42	6 mo	-3.9kg†	-5%	+2%	+8%	-8.5kg*†	0%	-23%*	+13%
Samaha/ Stern n=132	6 mo	-1.9kg†	+3%	-4%	-2%	-5.8kg*†	+4%	-20%*	0%
	12 mo	-3.1kg	-3%	+2%	-12%	-5.1kg	+6%	-29%	-2%
Foster n=63	6 mo	-5.3kg†	-3%	-13%	+4%	-9.7kg*†	+4%	-21%	+20%*
	12 mo	-4.5kg†	-6%	+1%	+3%	-7.3kg†	+1%	-28%*	+18%*
Yancy n=119	6 mo	-6.5kg	-3%	-15%	-1%	-12.0kg*	+2%	-42%*	+13%*
Meckling N=40	10 wks	-6.8kg	-32%	-25%	-15%	-7.0kg	0%	-29%	+12%

* $p<0.05$ for between-groups comparison



Dehghan, et al. Associations of fats and carbohydrate intake with cardiovascular disease and mortality in 18 countries from five continents (PURE): a prospective cohort study. The Lancet , 2017:390 , 10107 , 2050 - 2062



第1页 共1页

首都医科大学附属北京世纪坛医院检验报告单

姓 名 [redacted]
性 别：女
年 龄：35岁
病案号：384352

样 本 号：52
患者编号：0000503256
科 室：临床营养科
病 床 号：

病 区：
样本种类：静脉血（全血）
条 码 号：18071702523
临床诊断：肥胖

备 注：
采 样 者：胡晴雯
送检医师：江波

序号	项目名称	项目简称	结果	单位	参考范围
1	糖化血红蛋白	HbA1c%	5.1	%	4.0-6.0

第2页

首都医科大学附属北京世纪坛医院检验报告单

姓 名 [redacted]
性 别：女
年 龄：35岁
病案号：384352

样 本 号：219
患者编号：0000503256
科 室：临床营养科
病 床 号：

病 区：
样本种类：静脉血（空腹）
条 码 号：18071702522
临床诊断：肥胖

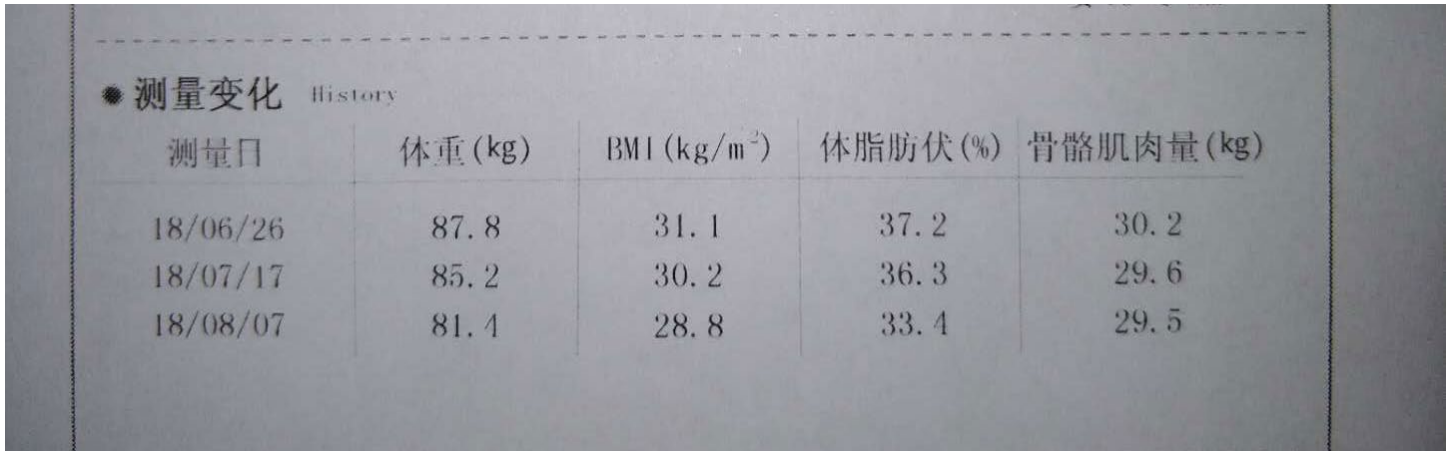
备 注：
采 样 者：胡晴雯
送检医师：江波

序号	项目名称	项目简称	结果		单位	参考范围
19	★总胆固醇	CHOL	4.03		mmol/L	3.0-5.7
20	★甘油三酯	TRIG	1.91	↑	mmol/L	0-1.7
21	★血清葡萄糖	GLU	4.43		mmol/L	3.9-6.1
22	★肌酸激酶	CK	<25.0	↓	U/L	40-200
23	★乳酸脱氢酶	LDH	125		IU/L	120-250
24	a—羟丁酸脱氢酶	HBDH	111		IU/L	72-182
25	★钙	CA	2.38		mmol/L	2.11-2.52
26	★磷	IP	1.47		mmol/L	0.85-1.51
27	血清铁	FE	8.5		μmol/L	7.8-32.2
28	血清镁	MG	0.91		mmol/l	0.75-1.02
29	淀粉酶	AMY	75		IU/L	35-135
30	★高密度脂蛋白胆固醇	HDL-C	0.79	↓	mmol/l	1.10-1.74
31	★低密度脂蛋白胆固醇	LDL-C	2.46		mmol/l	0-3.64
32	载脂蛋白A1	ApoA1	0.97	↓	g/L	1.0-1.6
33	载脂蛋白-B	ApoB	1.01		g/L	0.60-1.20
34	血清脂蛋白（a）	Lp(a)	0.20		g/L	0-0.3
35	★钾	K	4.15		mmol/L	3.5-5.3
36	★钠	Na	140		mmol/l	137-147

样时间：2018.07.17 11:28　　收样时间：2018.07.18 08:40　　检验者：[illegible]　　审核者：[illegible]
验时间：2018.07.18 09:29　　报告时间：2018.07.18 11:08　　仪器方法：西门子全自动生化分析仪
明：此报告只对该样本负责！　　注：★ 标识为检验结果互认项目！　　地址：北京市海淀区羊坊店铁医路10号

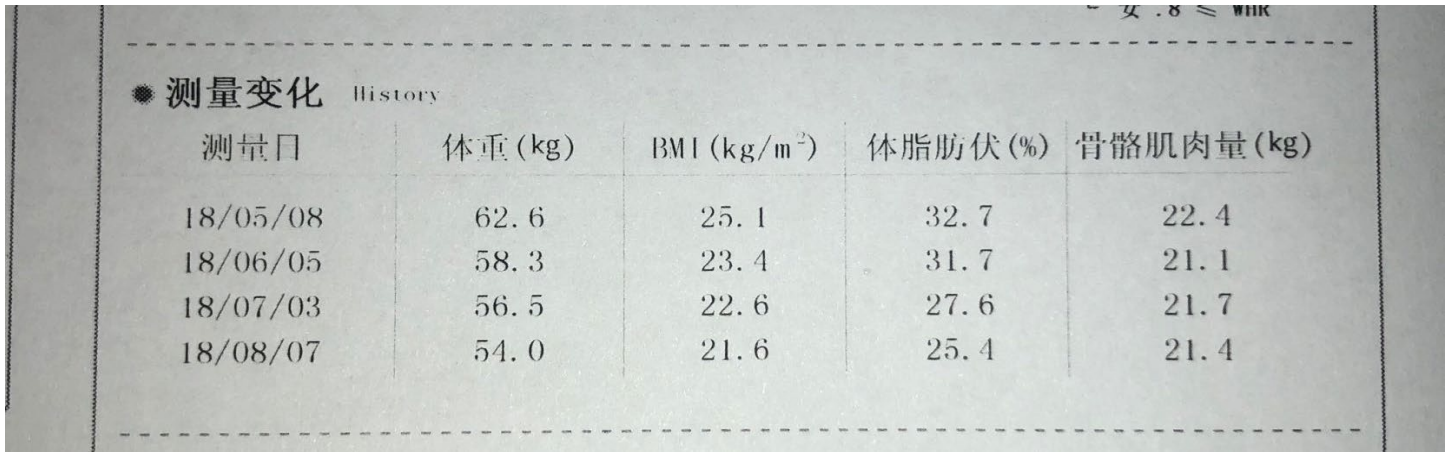

荣誉证书
荣誉证书


TOMMY



● 测量变化 History

测量日	体重(kg)	BMI(kg/m²)	体脂肪伏(%)	骨骼肌肉量(kg)
18/06/26	87.8	31.1	37.2	30.2
18/07/17	85.2	30.2	36.3	29.6
18/08/07	81.4	28.8	33.4	29.5

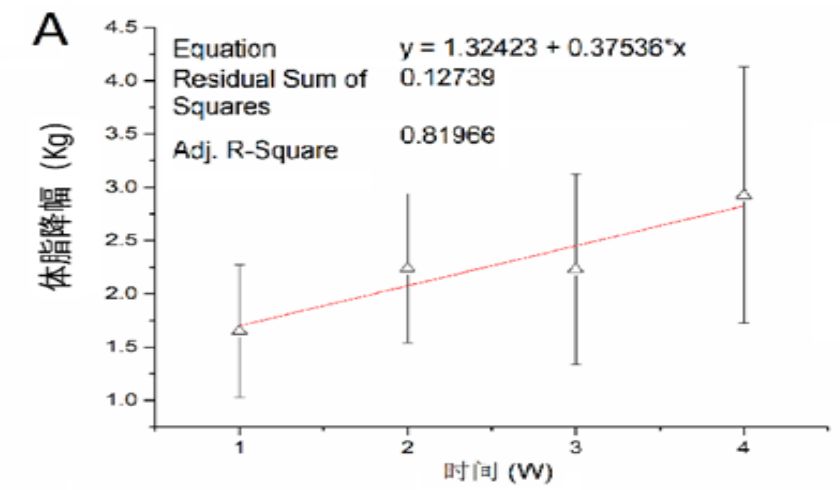


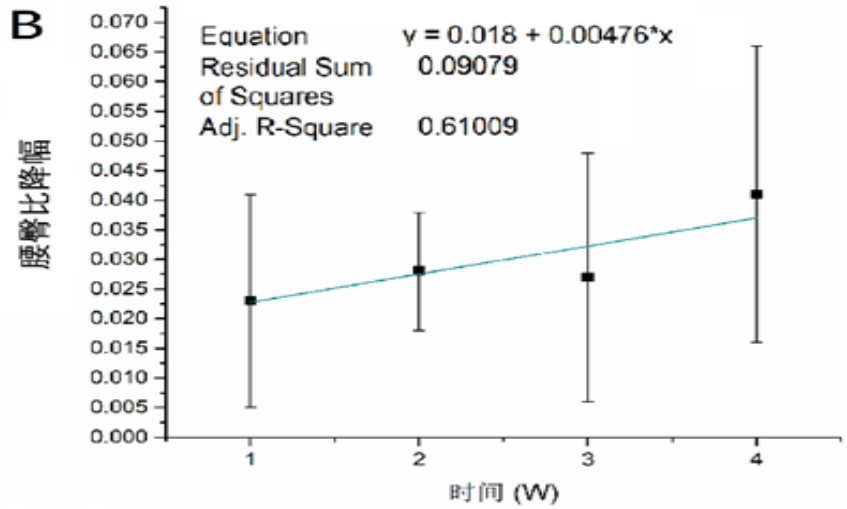
● 测量变化 History

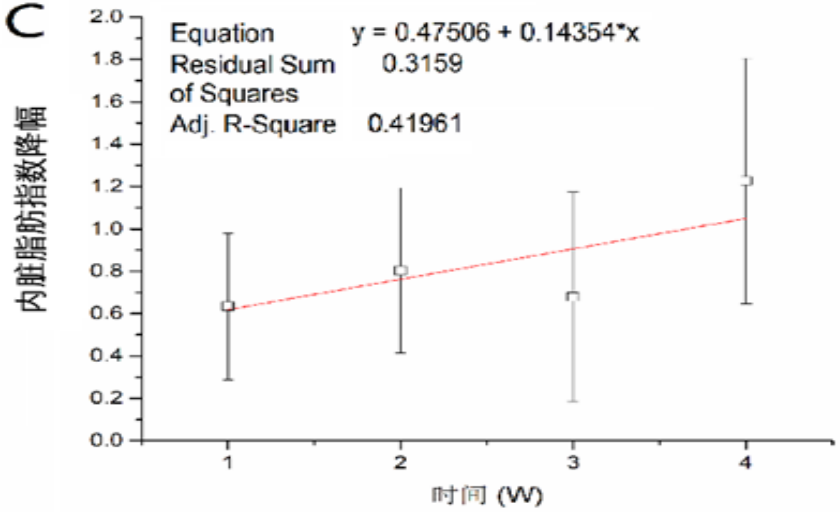
测量日	体重(kg)	BMI(kg/m²)	体脂肪伏(%)	骨骼肌肉量(kg)
18/05/08	62.6	25.1	32.7	22.4
18/06/05	58.3	23.4	31.7	21.1
18/07/03	56.5	22.6	27.6	21.7
18/08/07	54.0	21.6	25.4	21.4

减脂不减肌　　减腰不减胸

生酮饮食的临床应用研究　减脂





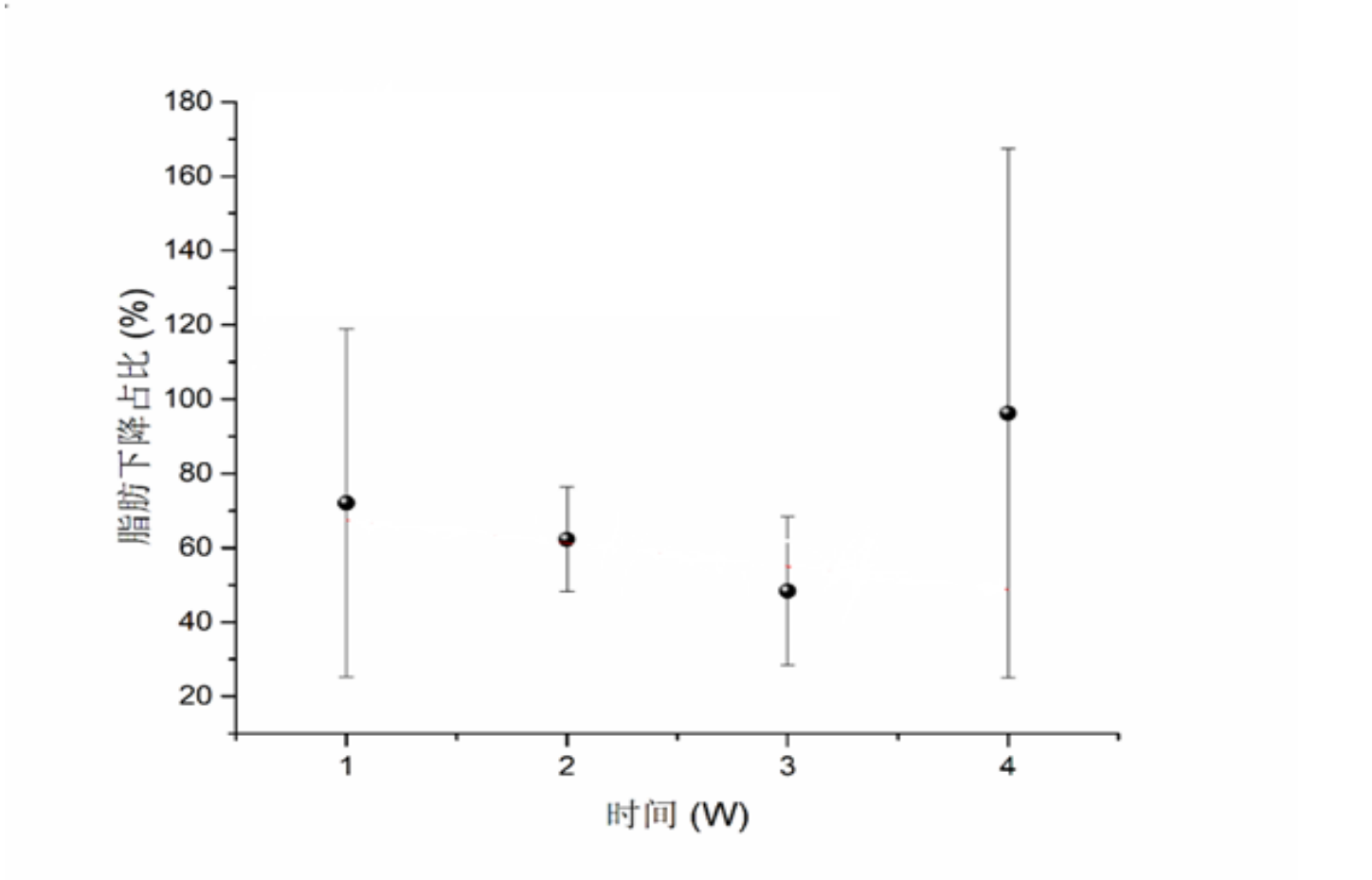


D

生酮减脂持续时间与体脂肪，腰臀比，内脏脂肪指数的关系

持续时间	1W	2W	3W	4W
体脂肪降低（Kg）	-1.649±0.621	-2.238±0.704	-2.232±0.896	-2.927±1.200
腰臀比降幅	-0.023±0.018	-0.028±0.018	-0.027±0.021	-0.041±0.025
内脏脂肪指数降幅	-0.634±0.345	-0.803±0.396	-0.679±0.495	-1.226±0.579

生酮饮食的临床应用研究　减脂



减少心脑血管病风险（strong evidence）

- 减少血总胆固醇水平，抑制内源性胆固醇的合成

  1）降低胰岛素水平，减少胰岛素对HMG-CoA 还原酶的诱导作用
  2）外源性胆固醇和脂肪摄入对内源性胆固醇合成的抑制作用

- 增加高密度脂蛋白

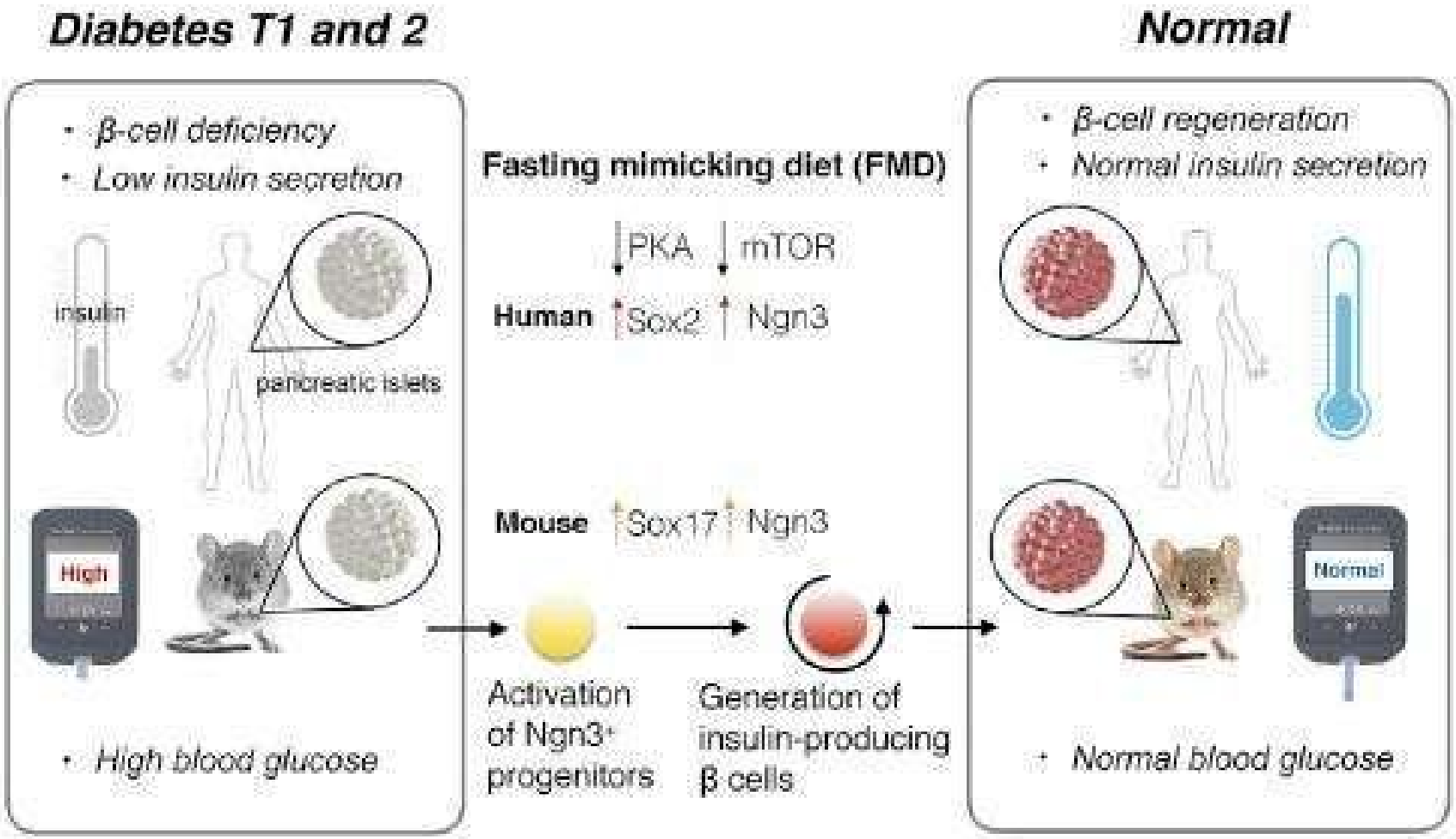
- 增加低密度脂蛋白-胆固醇颗粒的直径——被认为减少心血管疾病的风险

- 脂肪分解酶系的活化对VLCKD的消耗

- 降低血压

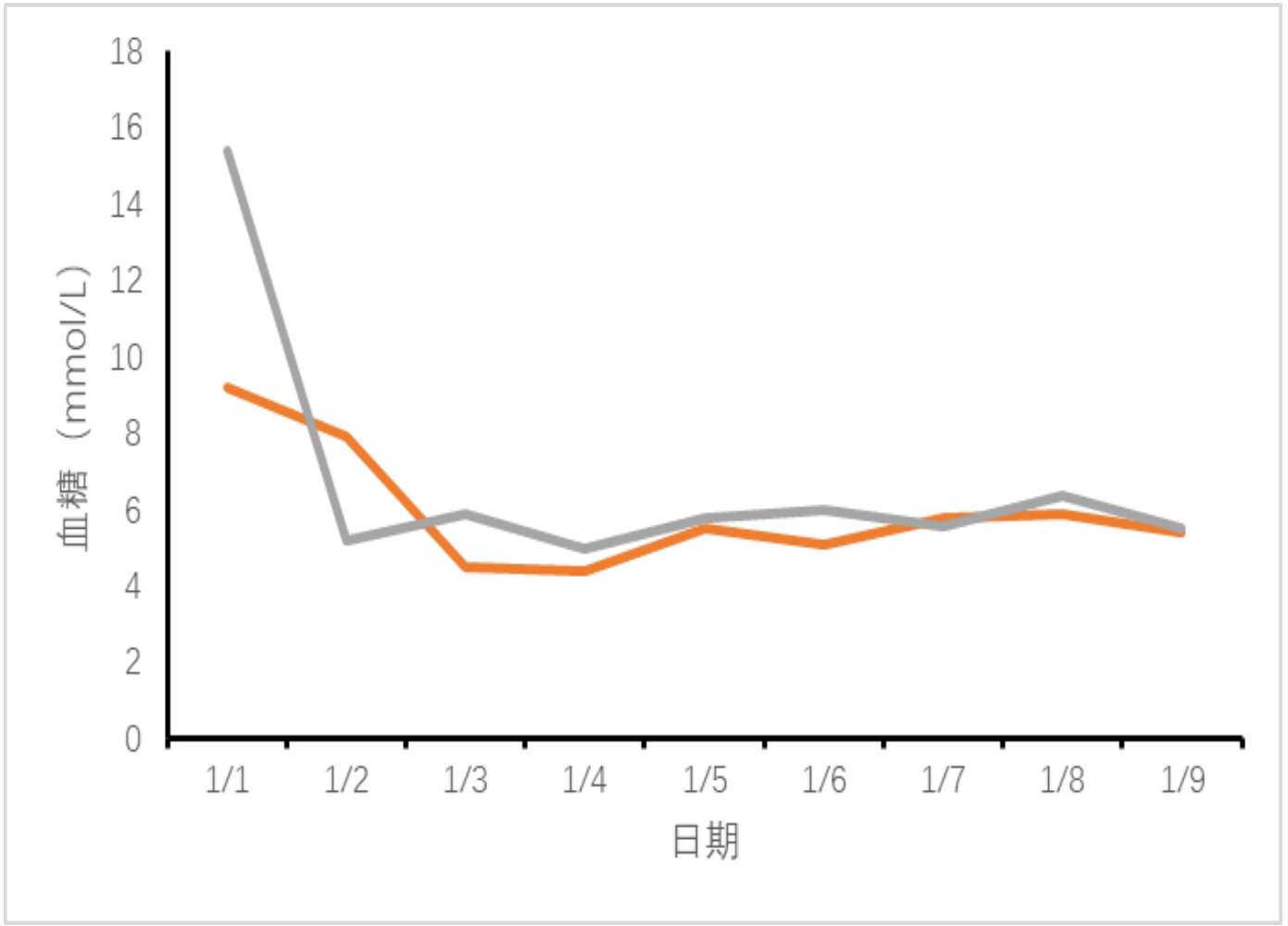
2型糖尿病（strong evidence）

- 增加胰岛素受体的敏感性（75%）
- 酮体水平和肝脏输出糖的能力呈现密切的负相关关系，原因不明。
- 降低高胰岛素血症导致的各种并发症的产生



Cheng CW. et al. Fasting-Mimicking Diet Promotes Ngn3-Driven β-Cell Regeneration to Reverse Diabetes. Cell, 23 February 2017, 168(5):775-788,
Wei M. et al. Fasting-mimicking diet and markers/risk factors for aging, diabetes, cancer, and cardiovascular disease. Sci Transl Med, 15 Feb 2017, 9(377), doi:10.1126/scitranslmed.aai8700.

生酮治疗的临床应用研究　糖尿病



Studies of ketogenic diet in type 2 diabetes

Year and site of the study	Sample description	Intervention and duration	Study parameters	Results
Westman *et al*. 2008 USA	84 obese and type 2 diabetic community volunteers 18-65 years with BMI: 27-50 kg/m^2	Randomly assigned LCKD and LGID Nutritional supplements and exercise recommended 24 weeks 49 (58.3%) completed study	HbA1c, fasting glucose, fasting insulin, weight loss, cholesterol	HbA1c, fasting glucose, fasting insulin, weight loss improved in both groups Significantly greater improvement among LCKD group in HbA1c (P=0.03) Body weight (P=0.008) HDL cholesterol (P<0.001) Reduced anti-diabetic drugs to 95.2% in LCKD group versus 62% in LGID group (P<0.01)
Dashti *et al*. 2007	64 healthy obese diabetic subjects	Study parameters determined before and at 8, 16, 24, 48 and 58 weeks after KD being administered	Body weight, BMI, blood glucose level, total cholesterol, LDL-cholesterol, triglycerides and urea	Significant reduction in body weight, BMI, blood glucose level, total cholesterol, LDL-cholesterol, triglycerides and urea from week 1-56 (P<0.0001) HDL-cholesterol increased significantly (P<0.0001) More significant results in subjects with hyperglycemia
Boden *et al*. 2005 University hospital	10 obese patients with type 2 DM	Inpatient comparison of 2 diets Usual diets for 7 days followed by KD for 14 days	Weight loss, 24-h blood glucose profiles, insulin sensitivity HbA1c, triglyceride and cholesterol levels	KD resulted in significant Spontaneous reduction in energy intake Weight loss Improved 24-h blood glucose profiles, insulin sensitivity, and HbA1c Decreased plasma triglyceride and cholesterol levels
Yancy *et al*. 2005 Durham VAMC clinic, USA	21 type 2 diabetic overweight participants 3 white, 8 African-American Mean±SD age 56.0±7.9 years BMI 42.2±5.8 kg/m^2	LCKD counseling Medication adjustment 16 weeks	HbA1c, fasting serum triglyceride, drug dosage and waist measurement	HbA1c decreased by 16% Mean body weight decreased by 6.6% Fasting serum triglyceride decreased 42% Reduction in antihyperglycemic medications Positive effect on waist measurement
Gumbiner *et al*. 1996	13 obese patients with type 2 diabetes	7 patients treated with high-ketogenic VLED for 3 weeks 6 patients treated with low-ketogenic VLED for 3 weeks Patients crossed over and treated with alternate diet for another 3 weeks	Fasting and OGTT plasma insulin, C-peptide concentrations and HGO	Fasting and OGTT glycemia were lower during treatment with high-ketogenic VLED (P<0.05) Strong correlation between basal HGO and fasting plasma ketone bodies (P<0.05) No significant difference in weight loss, fasting and OGTT plasma insulin and C-peptide concentrations

多囊卵巢综合征（PCOS）

- 纠正妇科内分泌紊乱

  LH/FSH>2~3　下丘脑GnRH脉冲发生器对雌、孕激素反馈不敏感

  降低雄激素水平

- 改善胰岛素抵抗

- 减少体脂率和降低脂肪组织净含量

妇科学组&多囊卵巢综合征协作组

生酮治疗PCOS的病例对照研究

生酮治疗PCOS的多中心队列研究

首都医科大学附属北京世纪坛医院
BEIJING SHIJITAN HOSPITAL, CMU
SJTH 首都医科大学肿瘤医学院 北京大学第九临床医学院

膳食指导干预多囊卵巢综合征项目受试者招募

尊敬的患者朋友：

目前我院妇科联合吴阶平医学基金会营养学部精准营养专业委员会共同进行一项关于“膳食指导改善多囊卵巢综合征的疗效研究”项目，项目负责人是白文佩主任医师和江波主任委员，目前已通过伦理委员会审查。

项目背景和简介：

多囊卵巢综合征是常见的生殖内分泌代谢性疾病，是育龄妇女不孕症最常见原因之一，发病率占育龄妇女的 5.6%。表现为月经周期不规律、不孕、多毛或痤疮、肥胖等。

符合以下条件可以报名参加该项目：

1. 确诊多囊卵巢综合征
2. 年龄 18-40 岁
3. 体重指数（体重/身高 ^{2}）≥24Kg/m^2，或体脂率≥28%
4. 三个月内暂无生育要求，能严格遵守营养师膳食指导

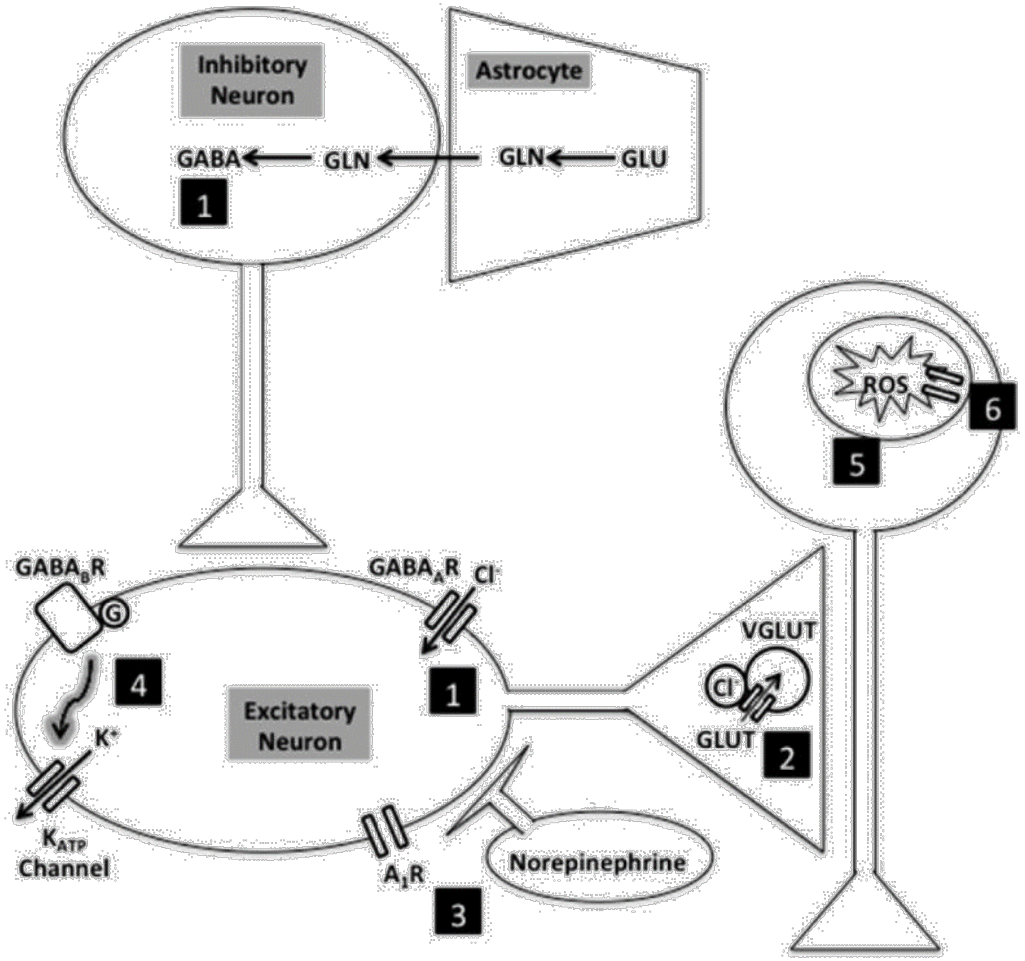
项目获益：

1、生酮饮食组免费获得三个月的个体化生酮饮食膳食指导。

2、均衡饮食组在研究周期结束后，可自愿选择三个月的免费生酮饮食指导。

3、两组患者均可以获得主管医生密切随诊及病情咨询。

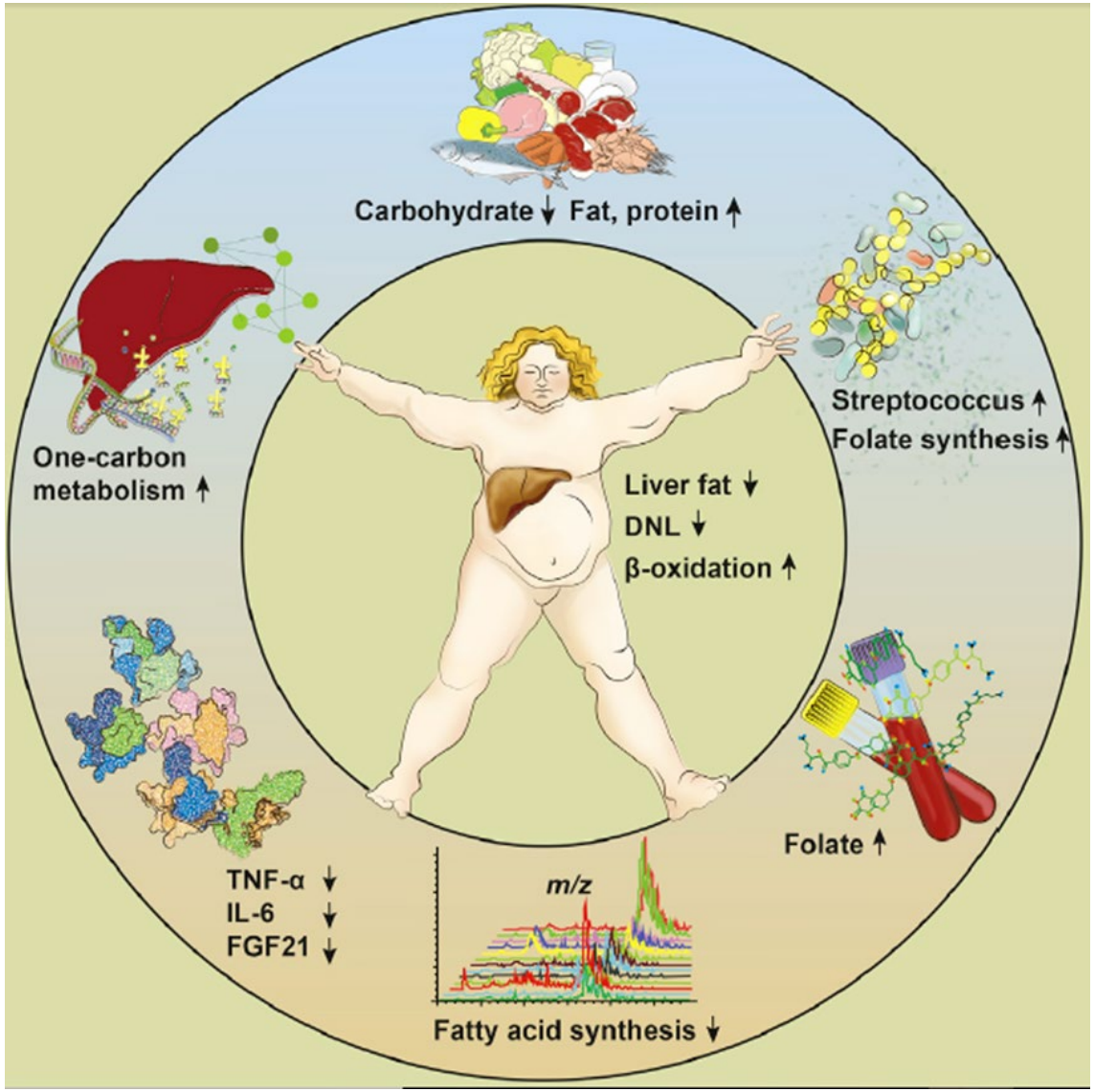
癫痫（strong evidence）



(1)通过改变谷氨酸-谷氨酰胺循环，增加GABA的合成。
(2) 竞争性抑制囊泡的谷氨酸转运体，抑制谷氨酸的释放。
(3)抑制其他神经递质，包括去甲肾上腺素和肾上腺素的释放。
(4) 通过KATP通道增加细胞膜的去极化
(5) 减少因为谷氨酸导致的ROS的产生

Melanie A. et al. Ketone bodies in epilepsy. J Neurochem. 2012 Apr; 121(1): 28–35.

脂肪肝



Adil Mardinoglu, et al. An Integrated Understanding of the Rapid Metabolic Benefits of a Carbohydrate-Restricted Diet on Hepatic Steatosis in Humans. Cell Metabolism, 2018.

疼痛

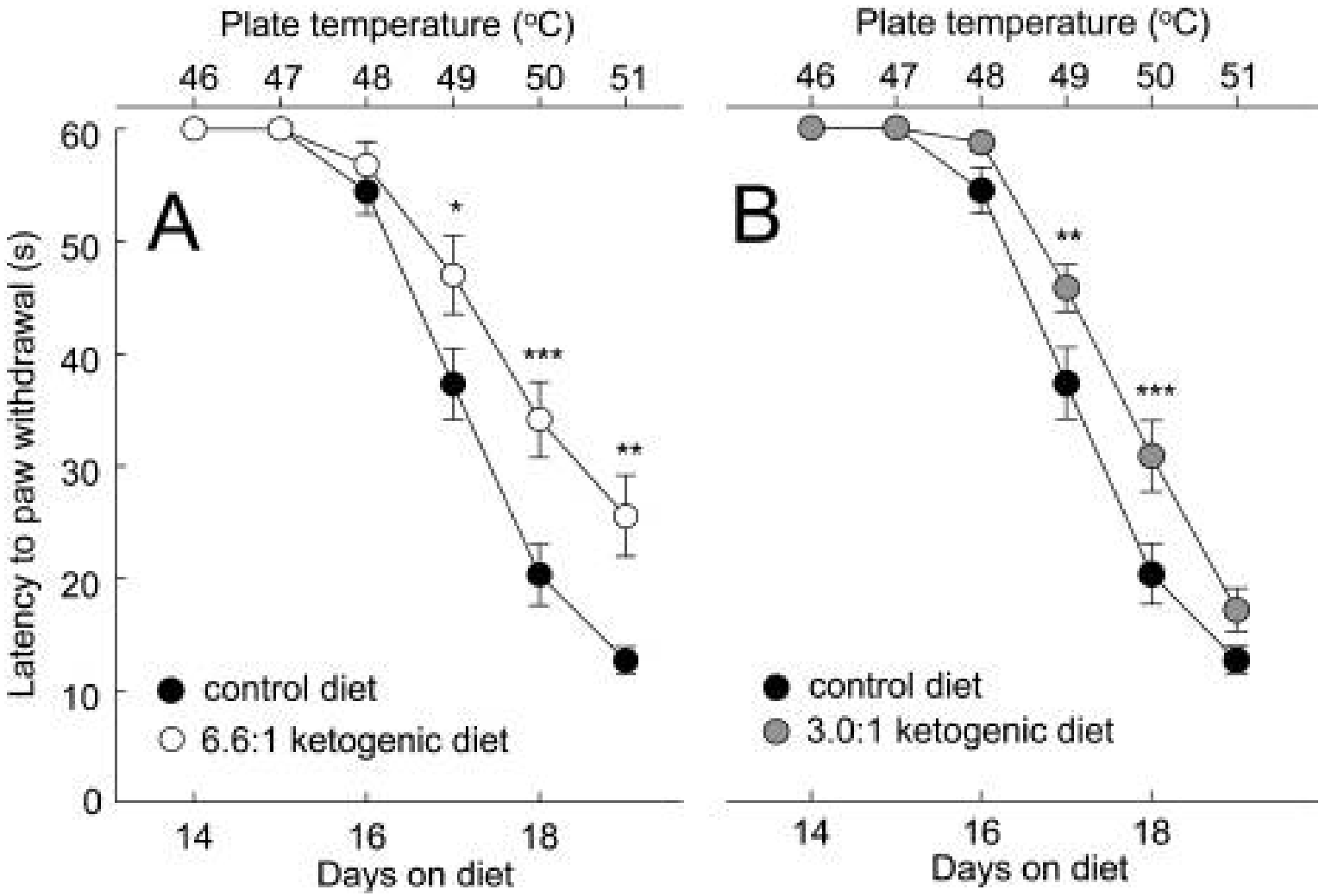
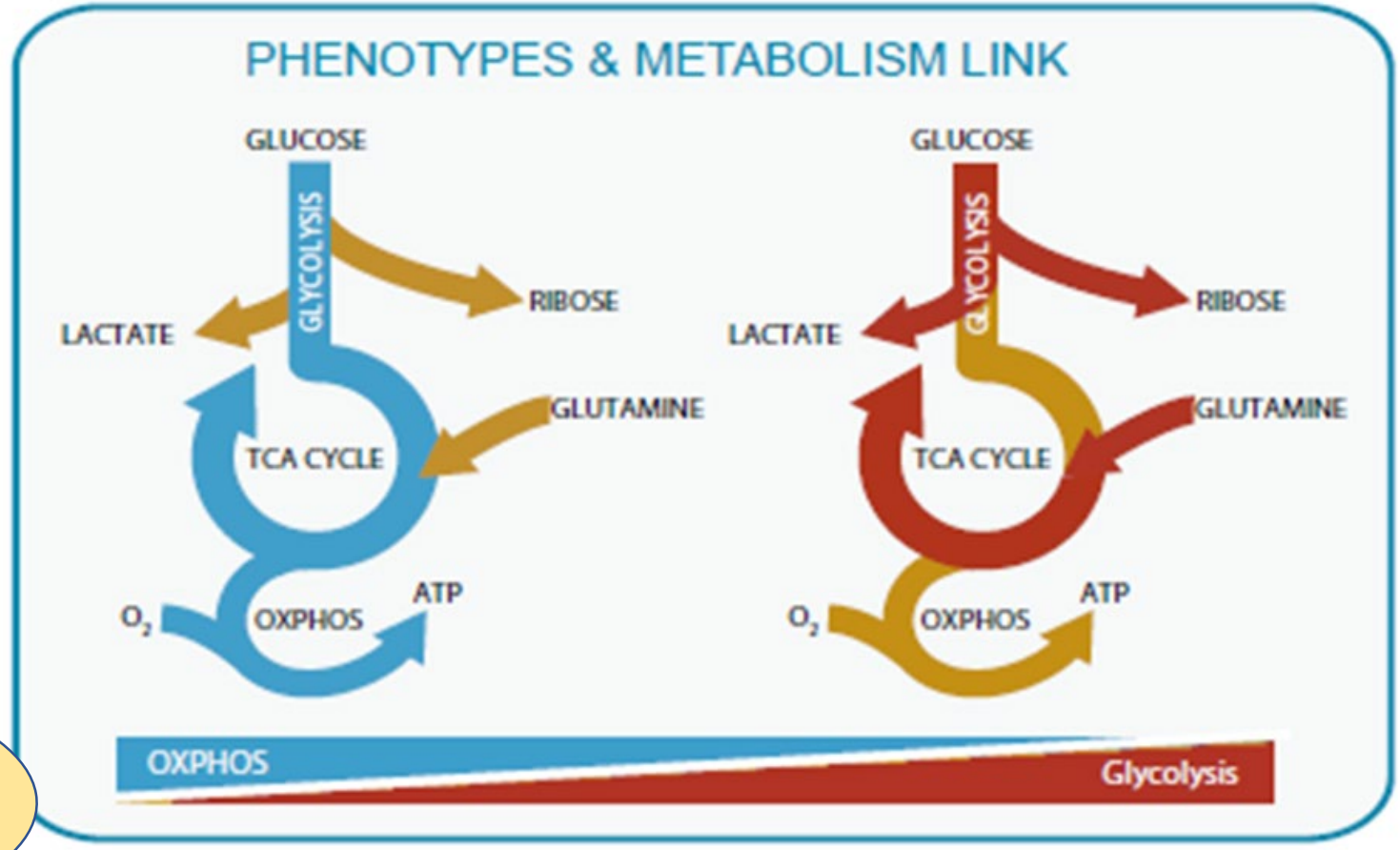


Plate temperature (°C)
46 47 48 49 50 51
A
B
Latency to paw withdrawal (s)
0 10 20 30 40 50 60
*
**
***
control diet
6.6:1 ketogenic diet
3.0:1 ketogenic diet
14 16 18
Days on diet

生酮对代谢的影响

无论是在有氧还是无氧的条件下，肿瘤细胞总是十分**“偏爱”**葡萄糖



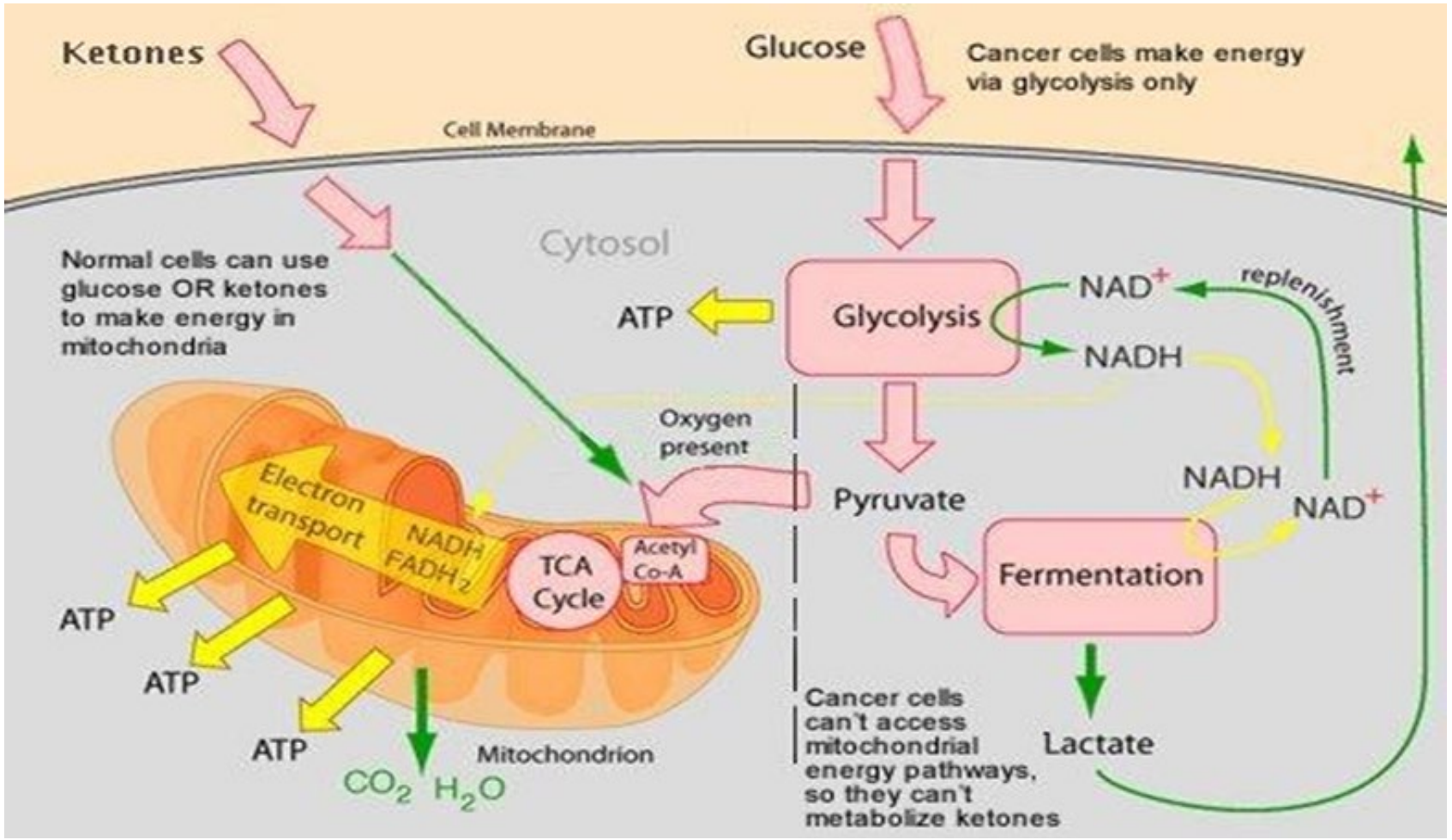
Warburg效应

和正常细胞相比肿瘤细胞对葡萄糖的需求明显增加

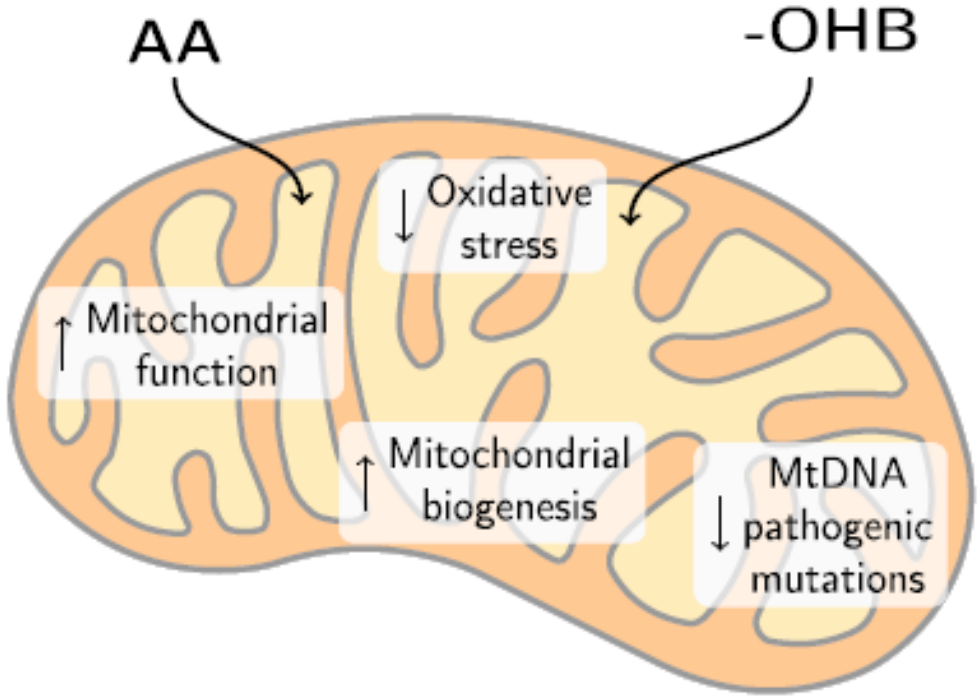
1）获取同样的能量，糖酵解需分解更多葡萄糖。

2）合成大分子物质需大量碳骨架。

生酮对代谢的影响——肿瘤细胞对酮体的利用能力下降



生酮对代谢的影响



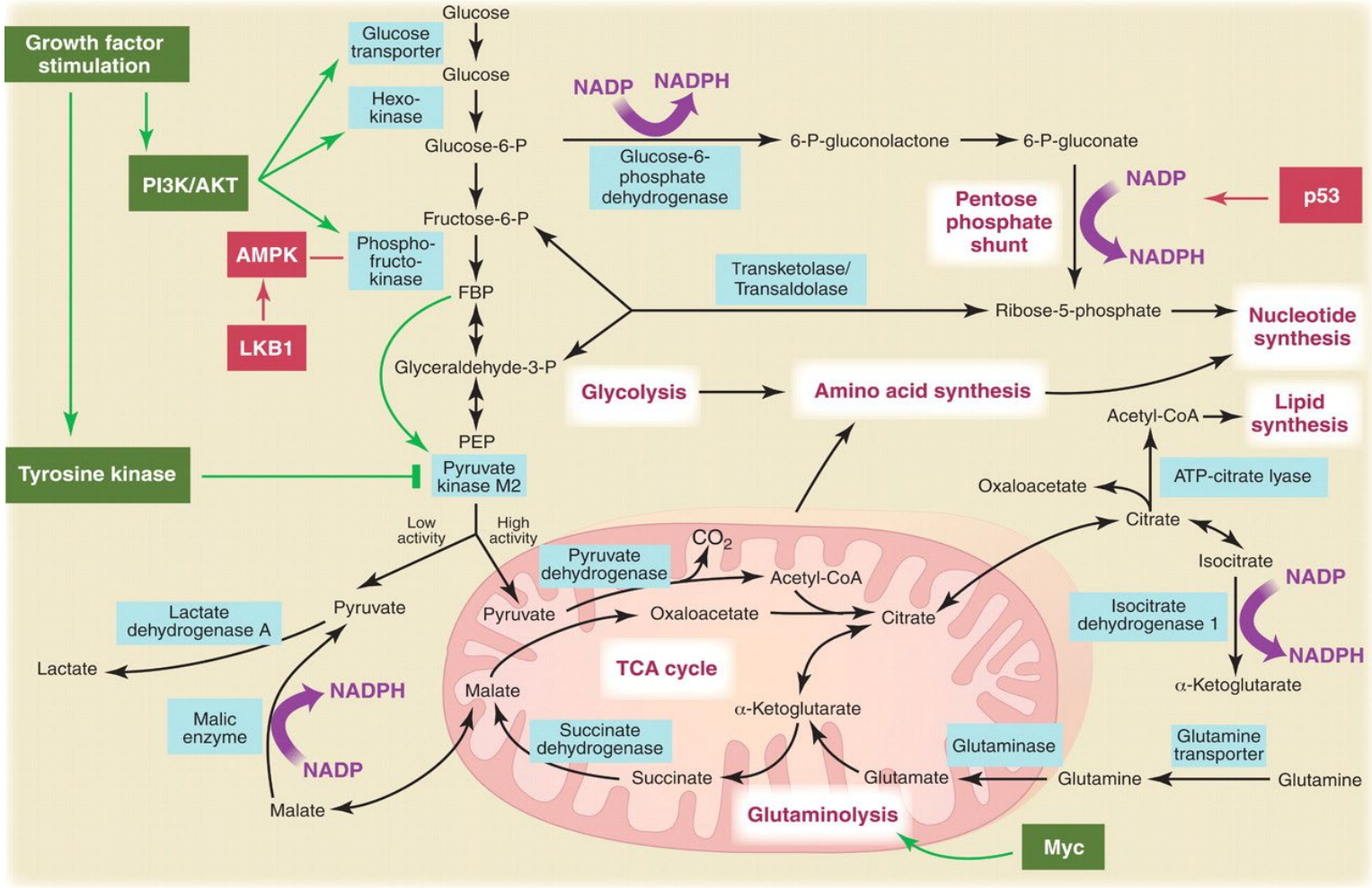
乙酰乙酸和β-羟基丁酸能够降低线粒体内的氧化压力，从而提高线粒体功能，促进线粒体的生成，降低线粒体DNA的病理性突变。

AF. Branco et al. *European Journal of Clinical Investigation*, 2016

与癌症相关的线粒体异常与可能影响肿瘤细胞对酮体的代谢，而酮体能够改善线粒体的功能 。

Seyfried TN, et al. ***Biochim Biophys Acta***, 2011

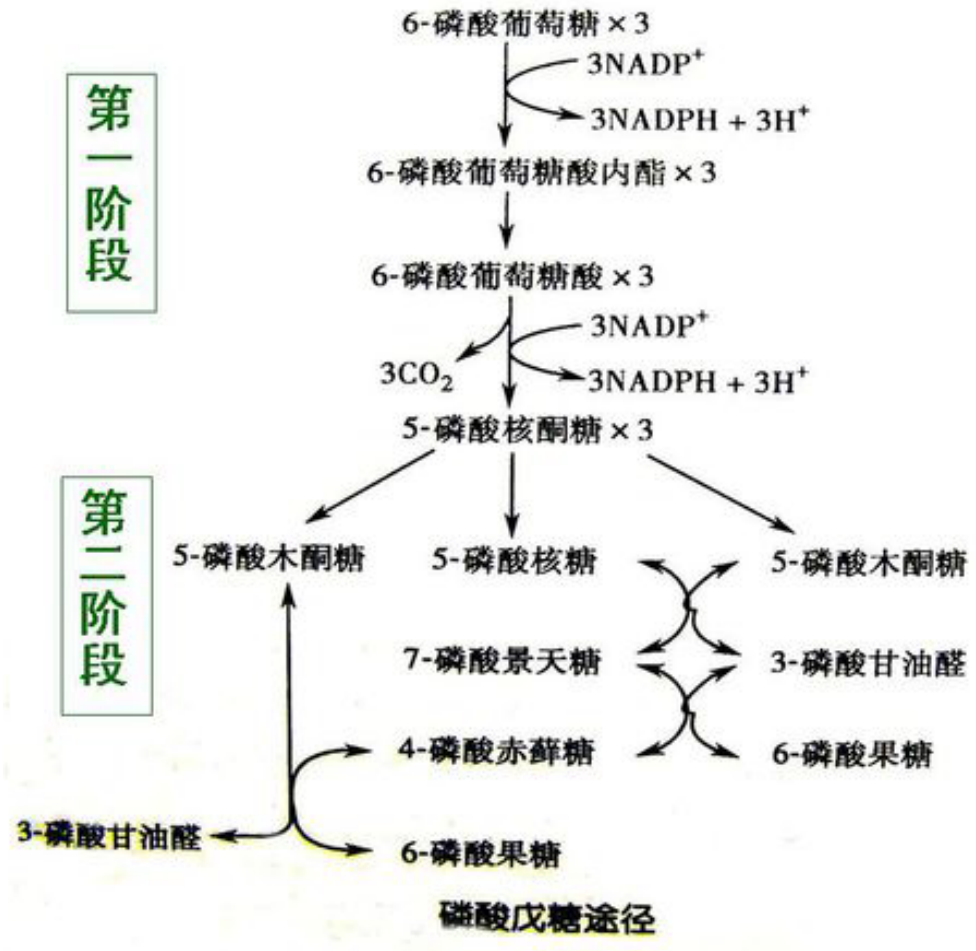
调控有氧糖酵解的主要信号通路



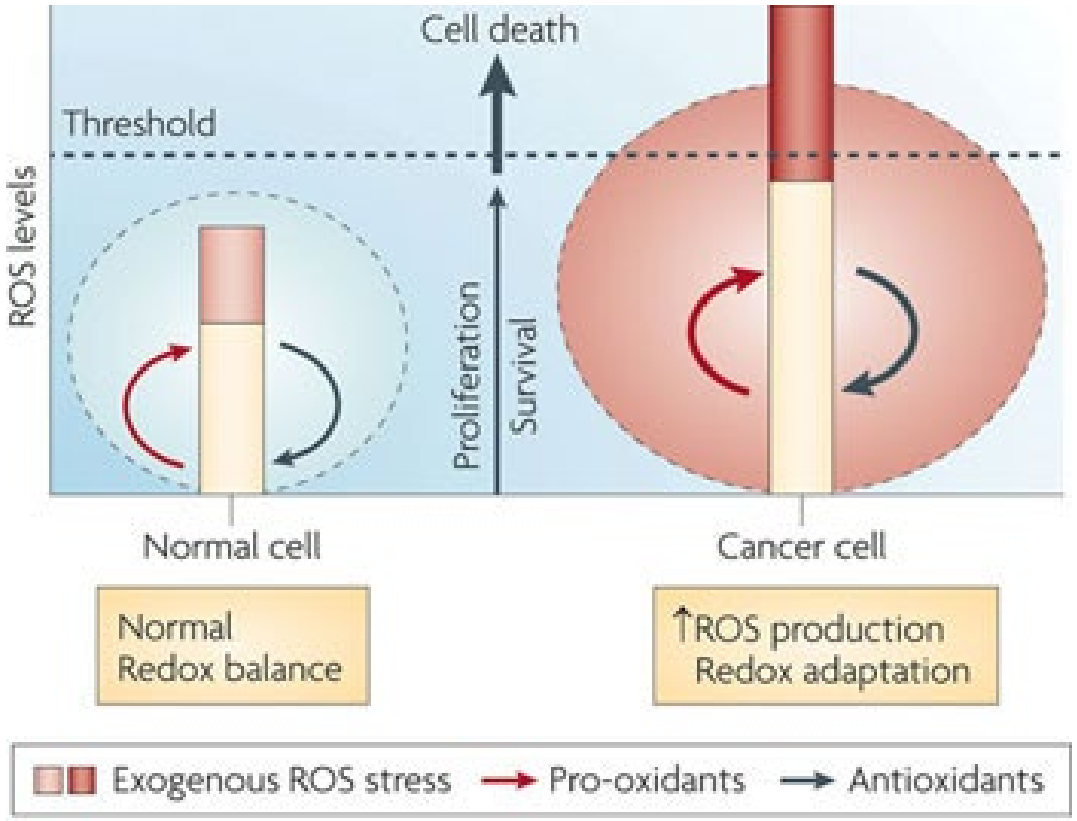
Vander Heiden M G, et al.. *Science*, 2009

LKB1-AMPK,PI3K/AKT及酪氨酸激酶等介导的信号通路。

磷酸戊糖途径和肿瘤细胞氧化应激



磷酸戊糖途径



Nature Reviews | Drug Discovery

生酮疗法治疗肿瘤脂类代谢相关酶系的改变

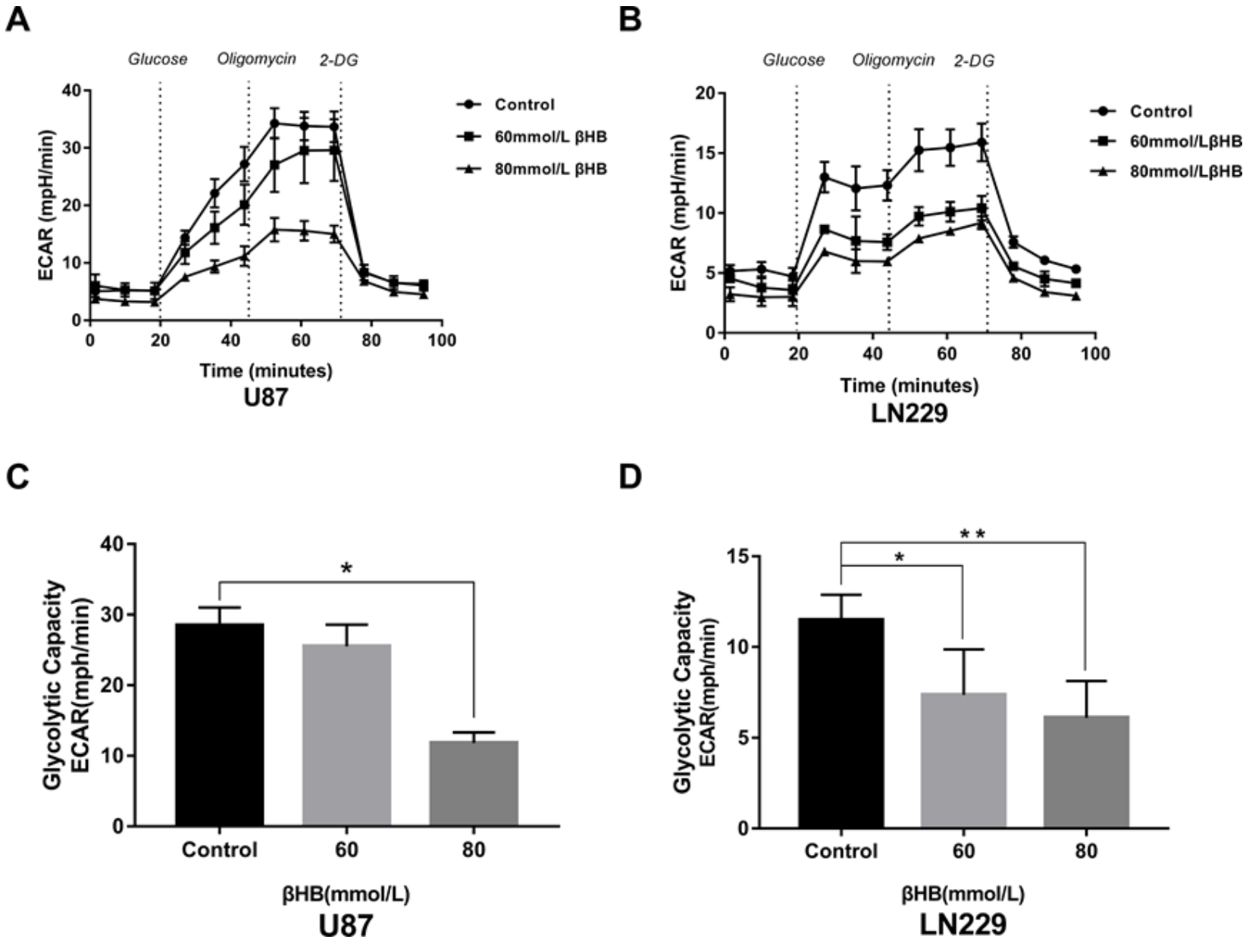
多种肿瘤中酮体利用关键酶β-OHBD和SCOT的表达显著下降

(Tisdale MJ, et al. *Br J Cancer,* 1983);

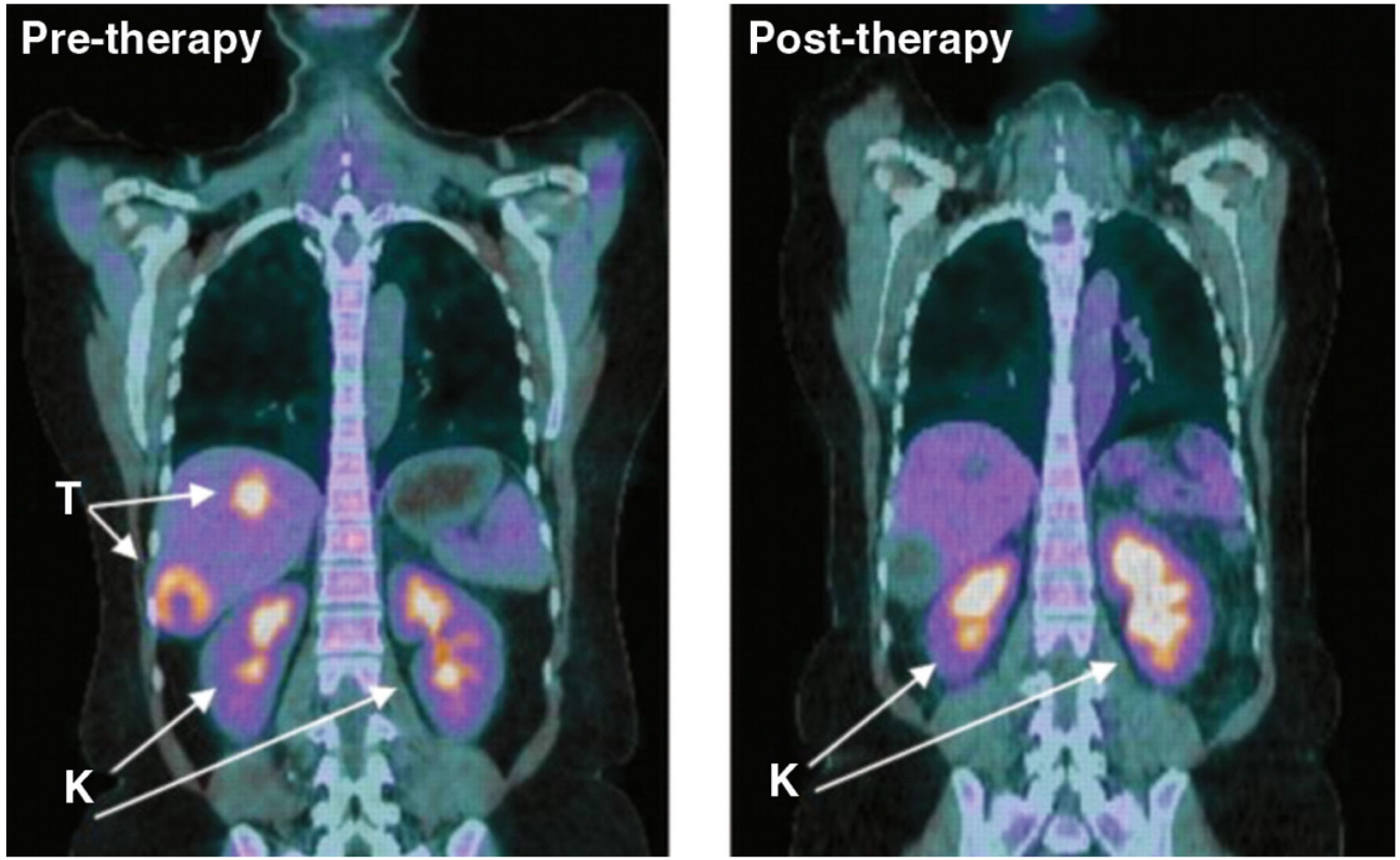
Table II Activity of 3-oxo acid CoA transferase

Tissue	*Activity* $\mu mol\,min^{-1}\,mg^{-1}$ *protein* ± *s.e.* ($n=3$)	*Relative activity* (% *of heart*) *value*
Normal		
Heart	12.5 ± 0.6	100
Kidney	7.1 ± 0.5	57
Lymphocytes	6.5 ± 0.5	52
Bladder	4.0 ± 0.5	32
Brain	2.6 ± 0.3	21
Intestine	2.4 ± 0.2	19
L132	1.25 ± 0.05	10
Liver	0.1 ± 0.04	0.8
Tumours		
M5076	0.65 ± 0.1	5.0
EJ	0.5 ± 0.06	4.0
TLX5	0.4 ± 0.004	3.0
MB	0.4 ± 0.03	3.0
P388	0.3 ± 0.04	2.8
PC6	0.2 ± 0.07	1.8
L1210	0.16 ± 0.06	1.3
W256	0.1 ± 0.05	0.8
K562	0.01 ± 0.005	0.1
RT112	0	0

我们的工作


A
Glucose
Oligomycin
2-DG
ECAR (mpH/min)
Time (minutes)
Control
60mmol/L βHB
80mmol/L βHB
U87
B
Glucose
Oligomycin
2-DG
ECAR (mpH/min)
Time (minutes)
Control
60mmol/LβHB
80mmol/LβHB
LN229
C
Glycolytic Capacity
ECAR(mph/min)
Control
60
80
βHB(mmol/L)
U87
D
Glycolytic Capacity
ECAR(mph/min)
Control
60
80
βHB(mmol/L)
LN229

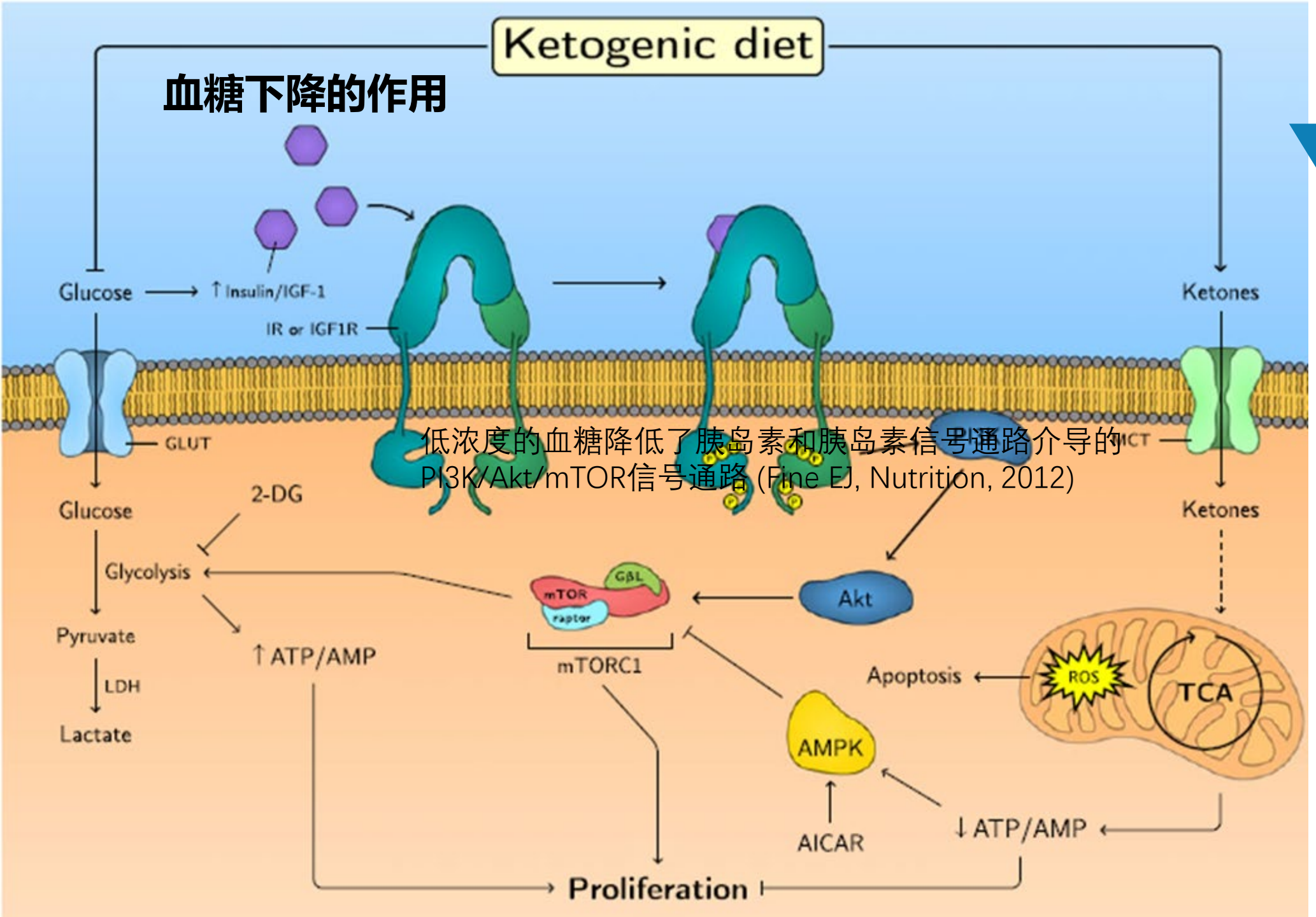
PET-CT评估肿瘤组织的糖摄取能力



T – tumor in liver (pre- and post-therapy)
K – kidney (does not contain tumor but concentrates FDG)

Source: *Science* 324, 1029 (2009).

血糖下降的作用



低浓度的血糖降低了胰岛素和胰岛素信号通路介导的PI3K/Akt/mTOR信号通路 (Fine EJ, Nutrition, 2012)

低浓度的血糖降低了胰岛素和胰岛素信号通路介导的PI3K/Akt/mTOR信号通路

(Fine EJ, *Nutrition,* 2012)

调控生酮的信号通路

碳水化合物的限制

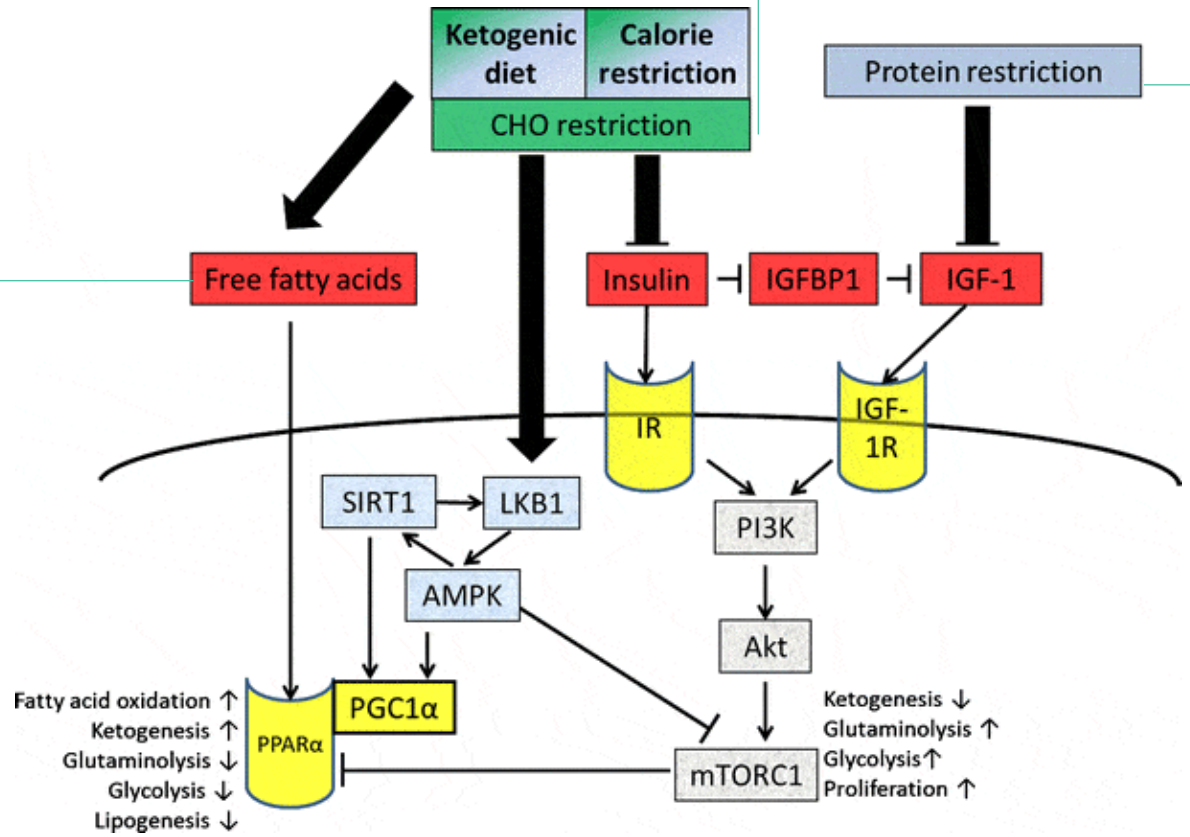
激活SIRT-LKB1-AMPK信号通路
胰岛素受体介导的信号通路

蛋白质限制

抑制IGF信号通路，
激活mTORC1

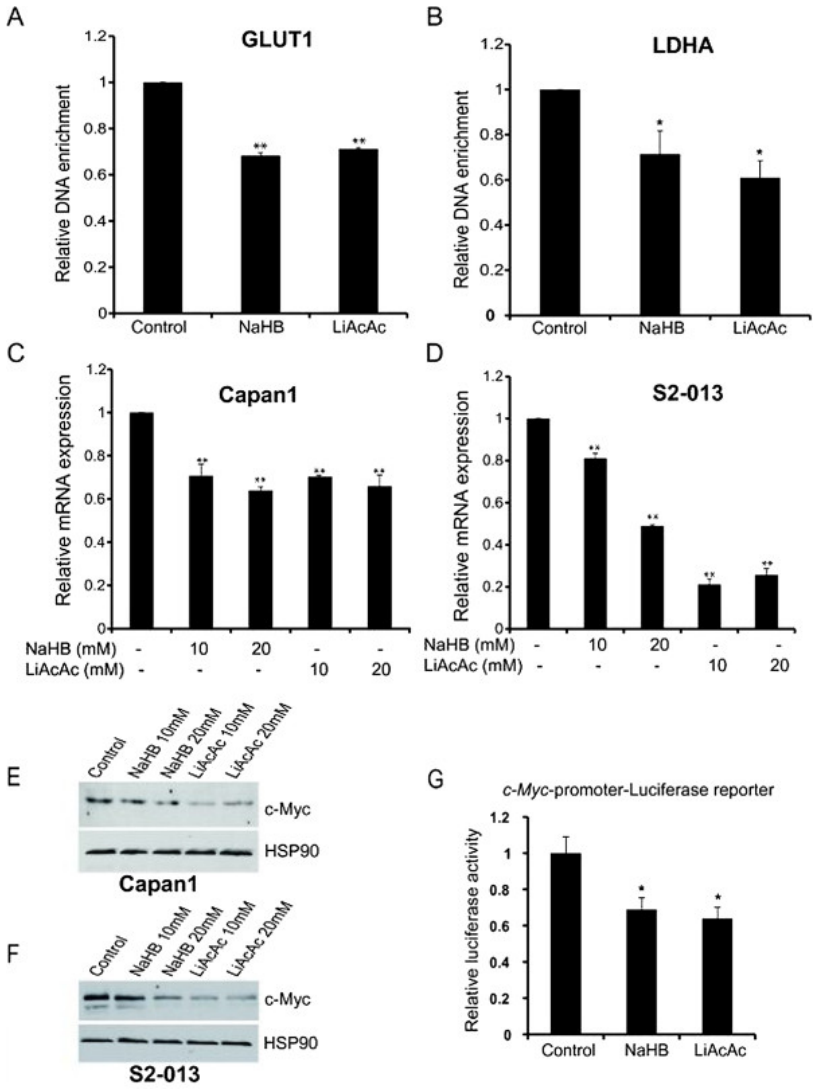
游离的脂肪酸

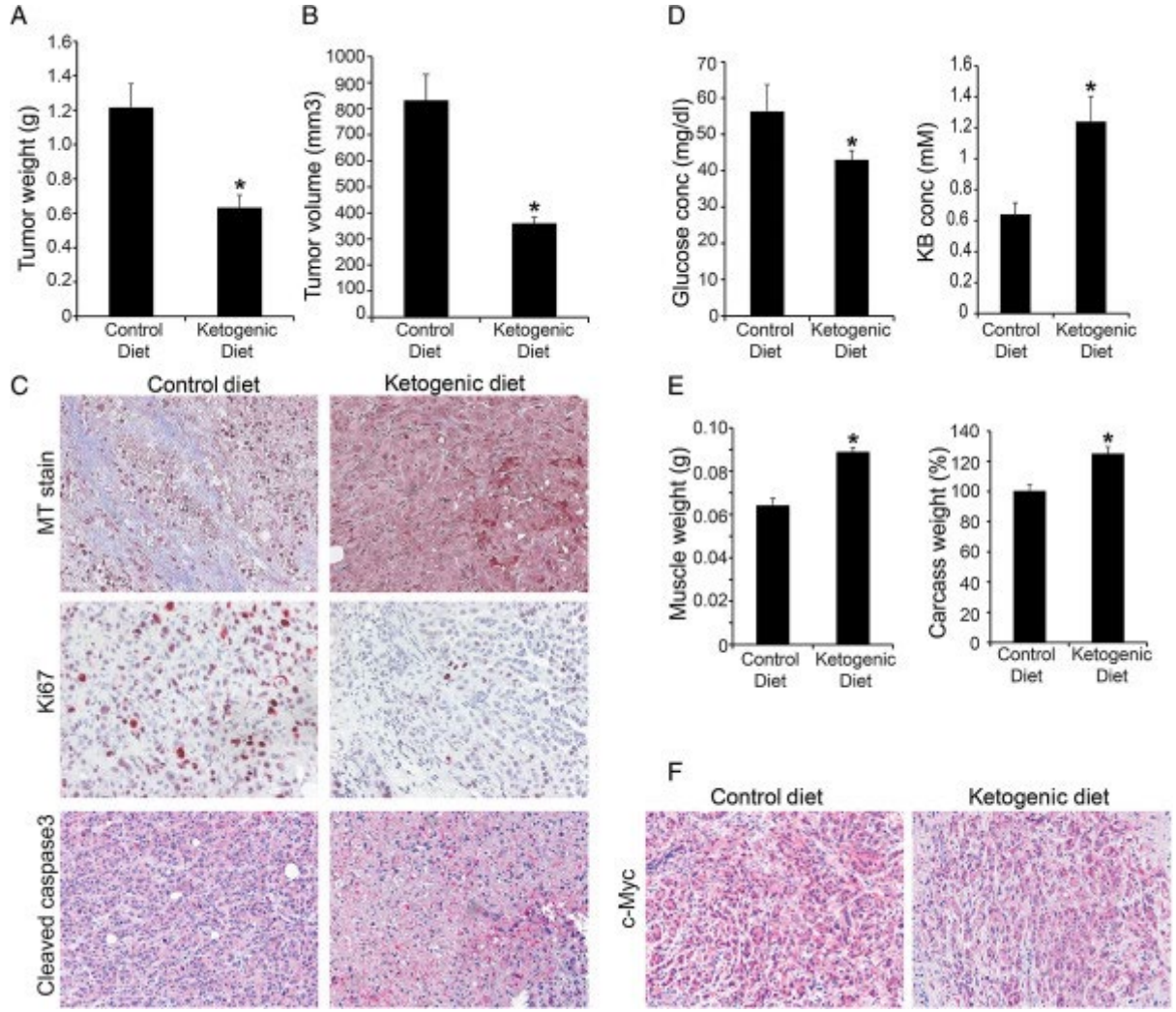
激活PPARα



Rainer J. Klement, et al. *Cancer and Metastasis Reviews*,2014

酮体直接抑制c-myc通路

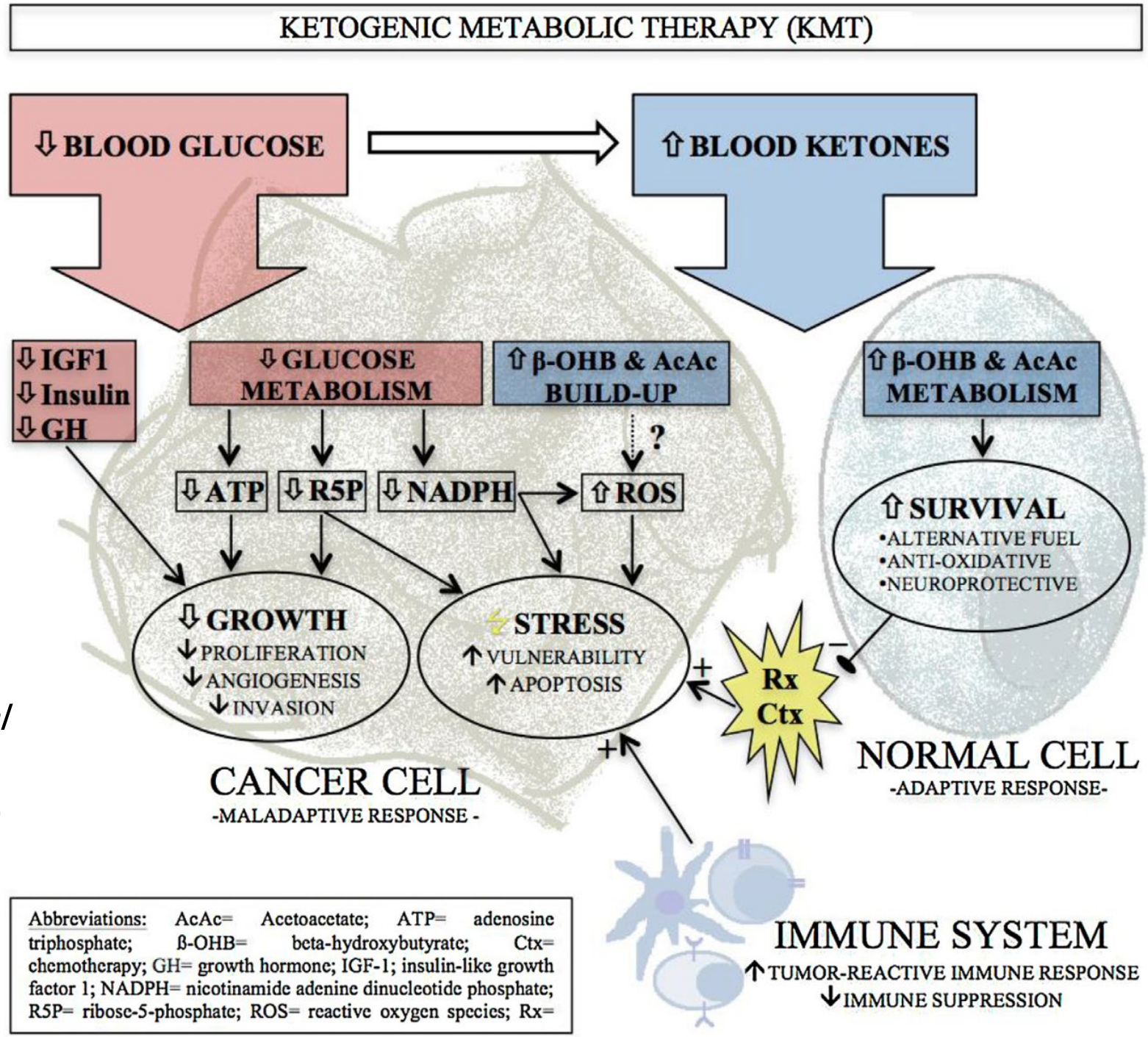




酮体改善营养状况增加肌肉保有量

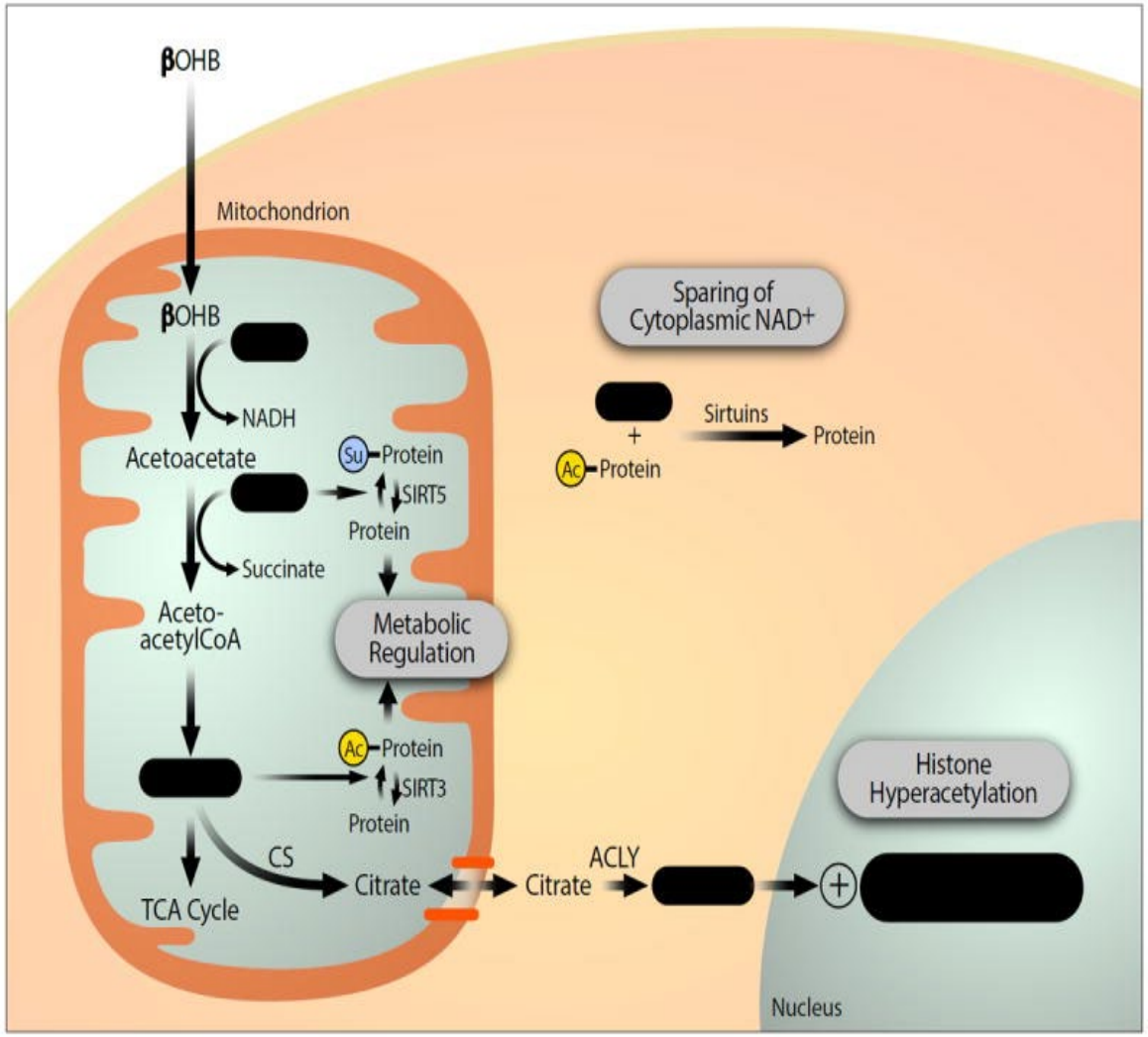
Surendra K Shukla, et al Cancer Metab. 2014; 2: 18.

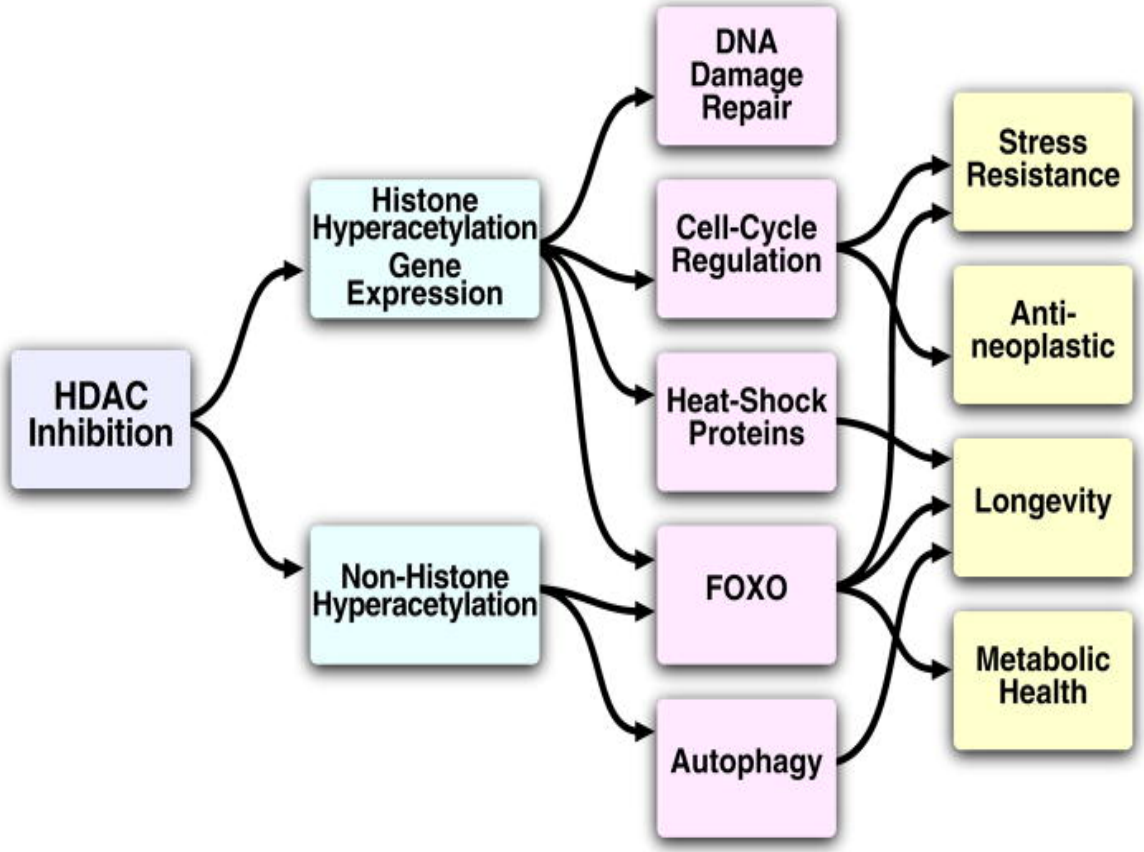
生酮代谢疗法治疗肿瘤的分子机制



SF. Wintera, et al. *Critical Reviews in Oncology/Hematology*, 2017

β-羟丁酸，不仅仅是代谢中间产物





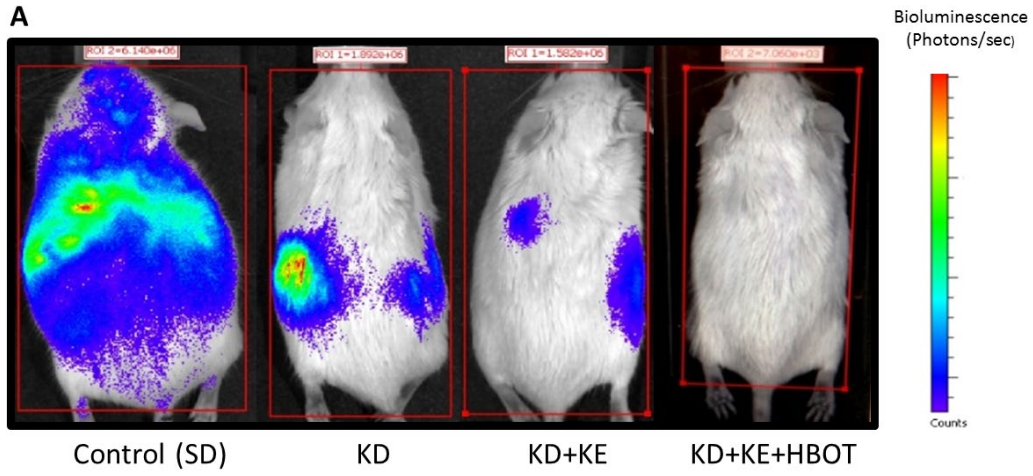
Newman JC, Verdin E，Diabetes Res Clin Pract. 2014 Nov;106(2):173-81.

β-羟丁酸，不仅仅是代谢中间产物

- Inhibitors of the TOR pathway
- Inhibitors of glycolysis
- Inhibitors of the GH/IGF-1 axis
- Activators of the sirtuin pathways
- Activators of the AMPK pathway
- Inhibitors of inflammatory pathways
- Modulators of epigenetic pathways

Valter D Longo, Adam Antebi, Andrzej Bartke, et al Aging Cell. 2015 Aug; 14(4): 497–510

生酮饮食和酮酯、高压氧的联合应用



A. M. Poff, et al. *PLoS One*, 2014

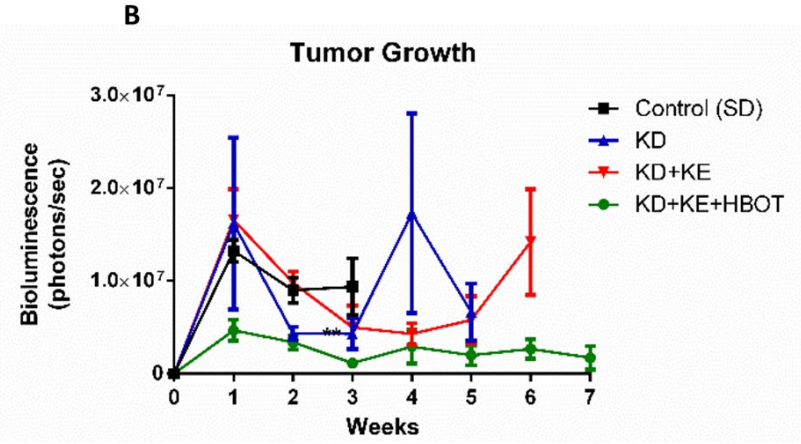
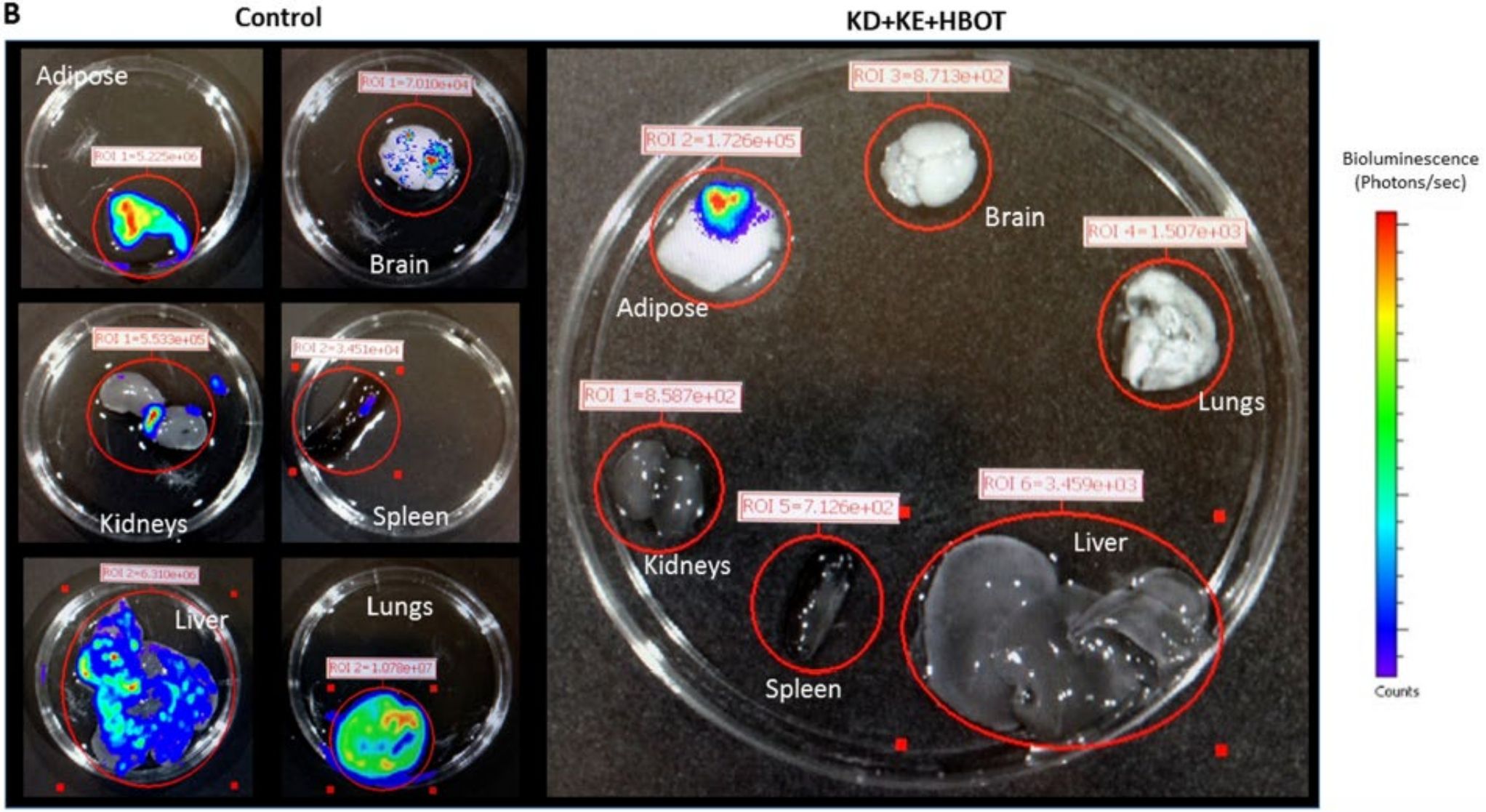


Table 1. Macronutrient information of diets and ketone ester.

Macronutrient Information	Standard Diet (SD)	Ketogenic Diet (KD)	Ketone Ester (KE)
% kcal from Fat	18.0	77.1	NA
% kcal from Protein	24.0	22.4	NA
% kcal from Carbohydrate	58.0	0.5	NA
Caloric Density	3.1 Kcal/g	4.7 Kcal/g	5.58 Kcal/g

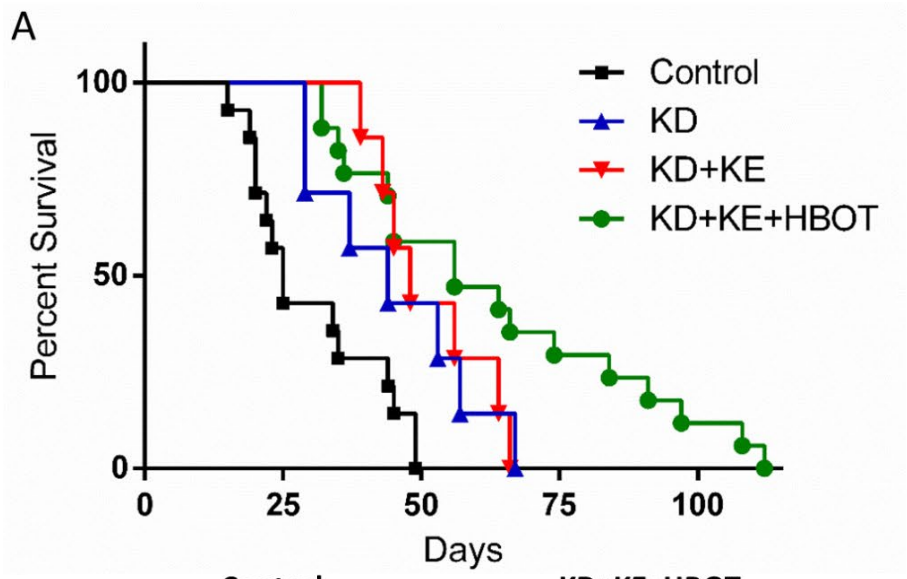
生酮饮食和酮酯、高压氧的联合应用



A. M. Poff, et al. *PLoS One*, 2014

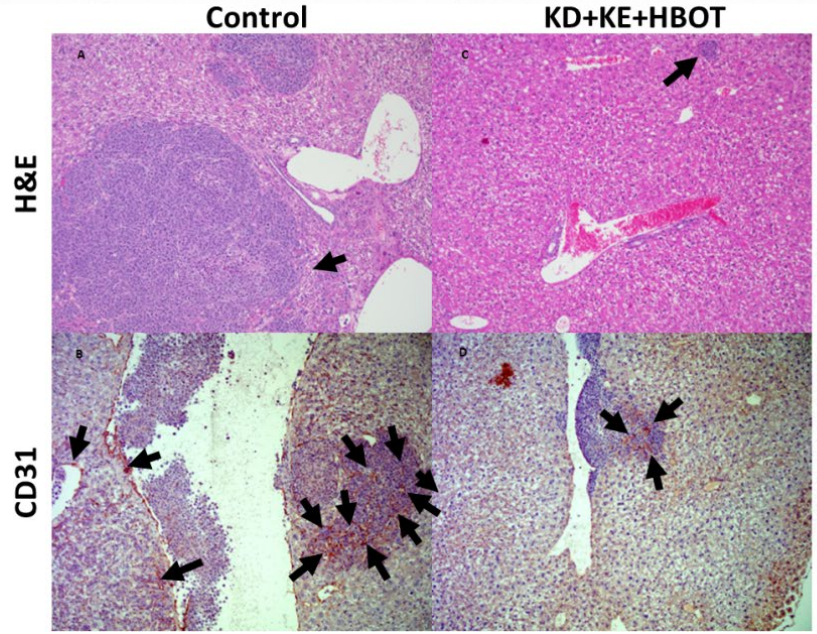
生酮饮食和酮酯、高压氧的联合应用

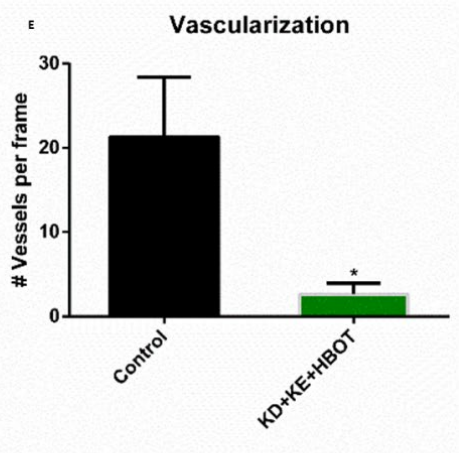
A



B

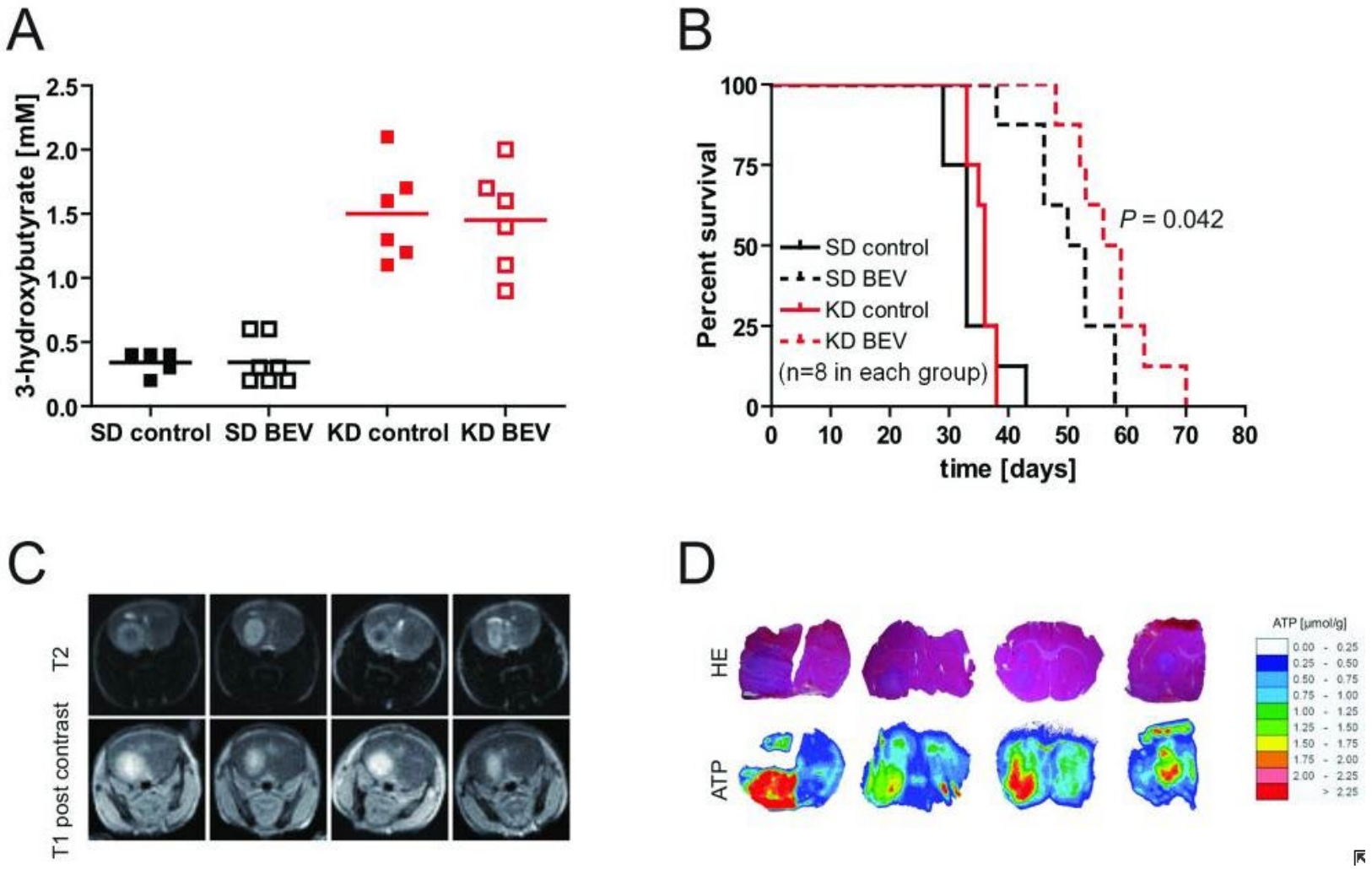
Treatment	Cohort Size	Mean Survival (days)	% Increase in Survival Time
Control (SD)	13	31.2	
KD	7	45.1	44.6*
KD+KE	7	51.6	65.4**
KD+KE+HBOT	17	63.4	103.2***



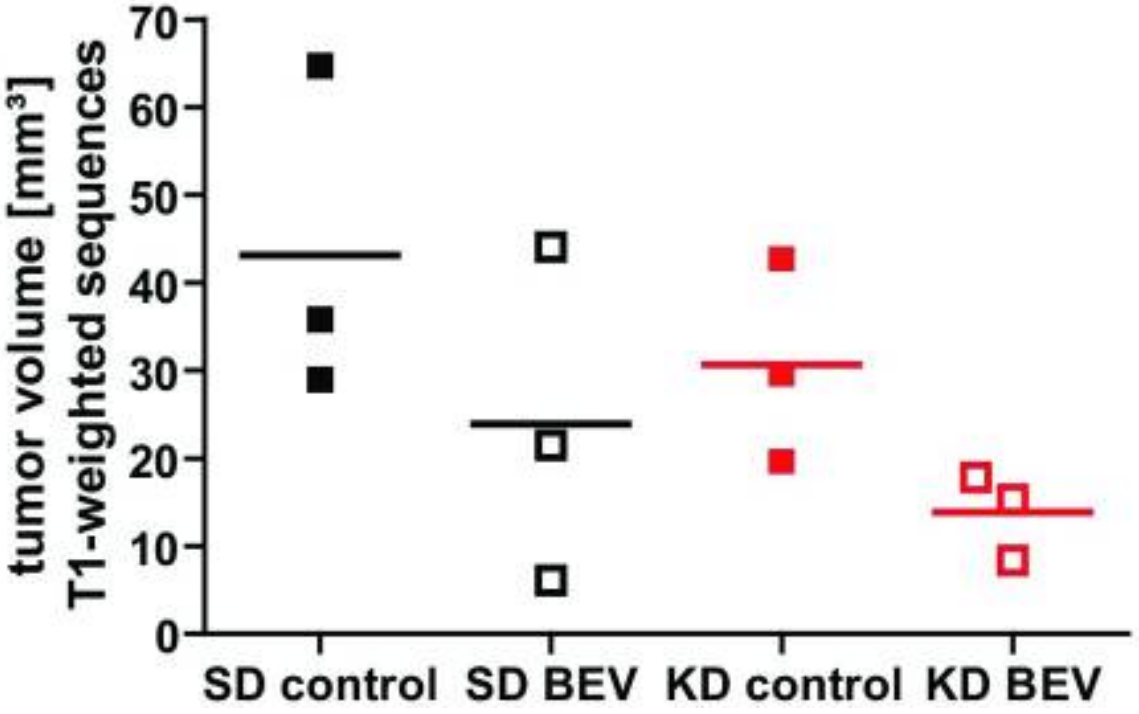


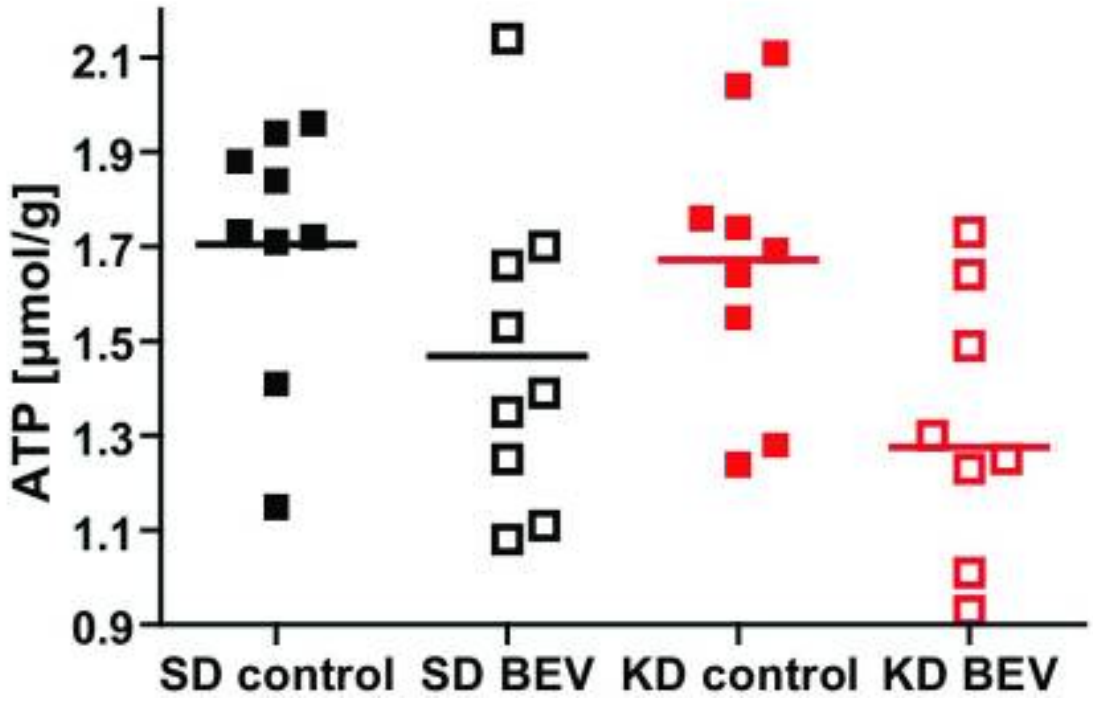
A. M. Poff, et al. *PLoS One*, 2014

生酮饮食抗新生血管生成药物的联合应用



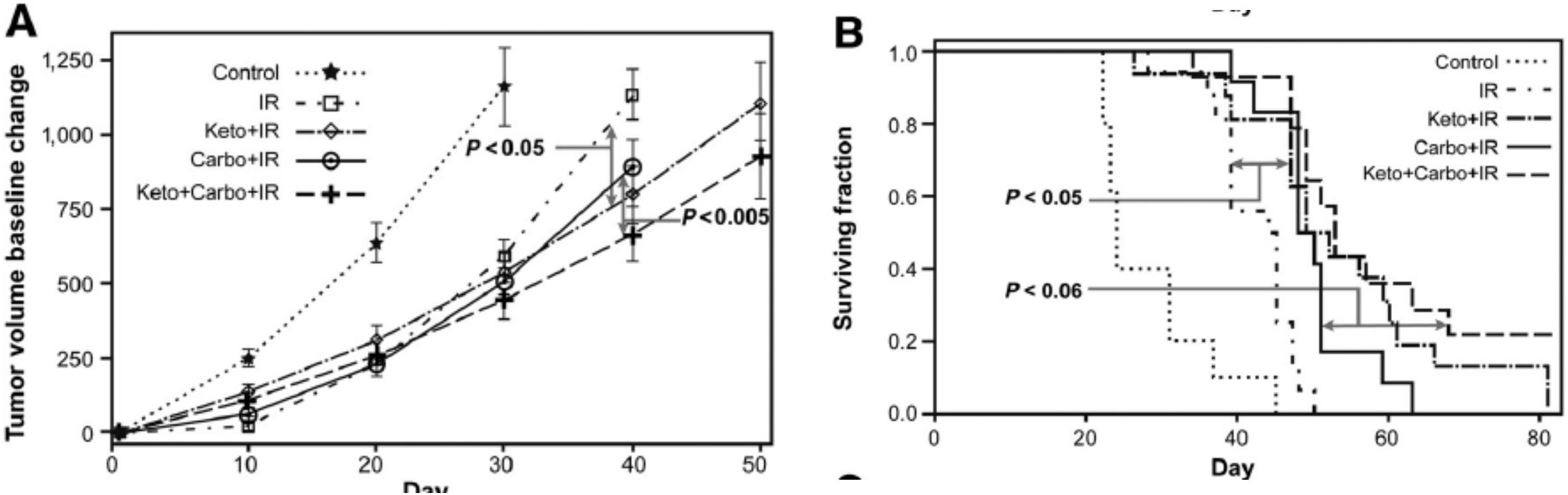
Johannes Rieger, *et al*. ERGO: A pilot study of ketogenic diet in recurrent glioblastoma. Int J Oncol. 2014 Jun; 44(6): 1843–1852.





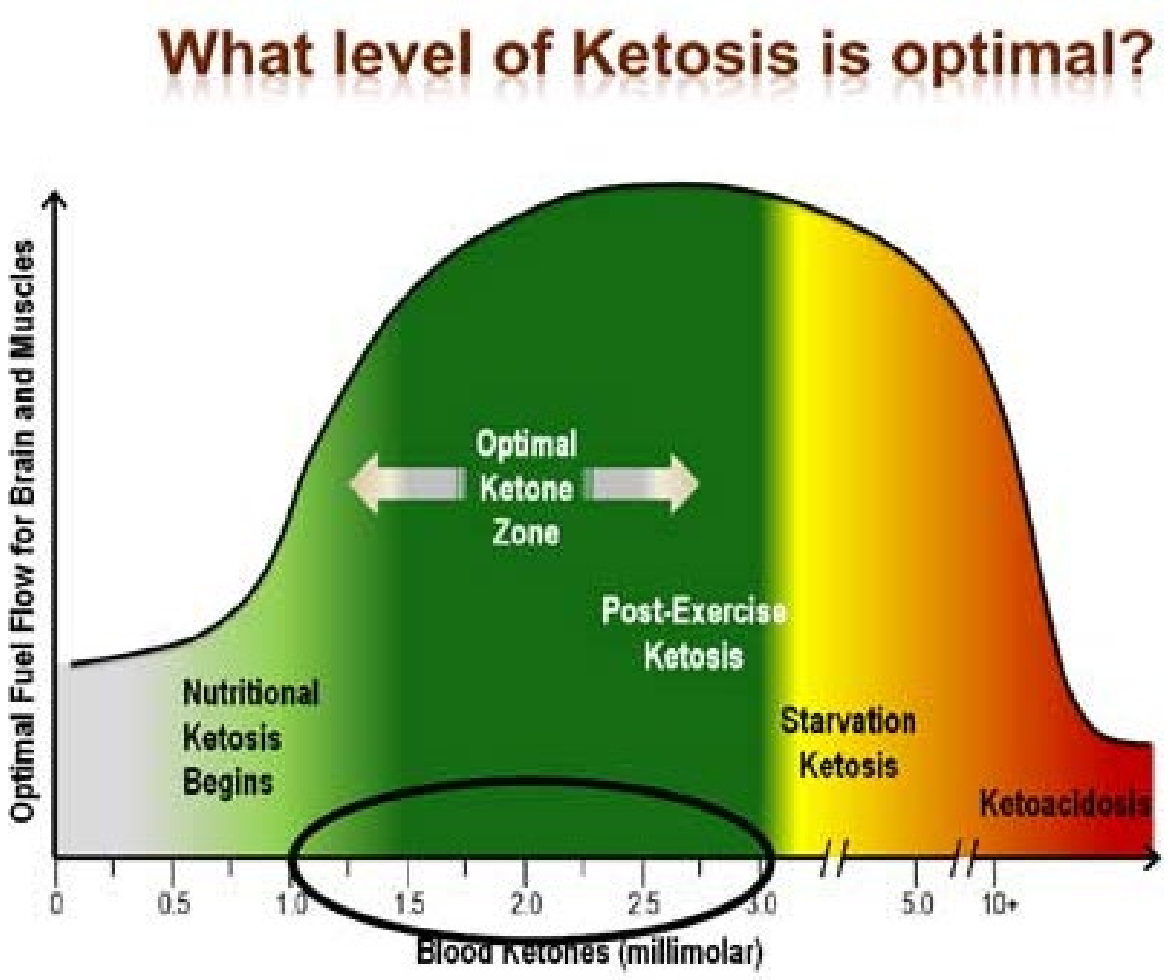
Johannes Rieger, *et al*. ERGO: A pilot study of ketogenic diet in recurrent glioblastoma. Int J Oncol. 2014 Jun; 44(6): 1843–1852.

生酮疗法与放疗对肺癌移植瘤的联合应用



Allen BG, et al. Clin Cancer Res. 2013 Jul 15;19(14):3905-13.

生酮饮食治疗肿瘤的最适浓度



G/K Index

$$\frac{\text{Glucose Measurement (mmol)}}{\text{Ketone Measurement (mmol)}} = 1.0 \text{ or below}$$

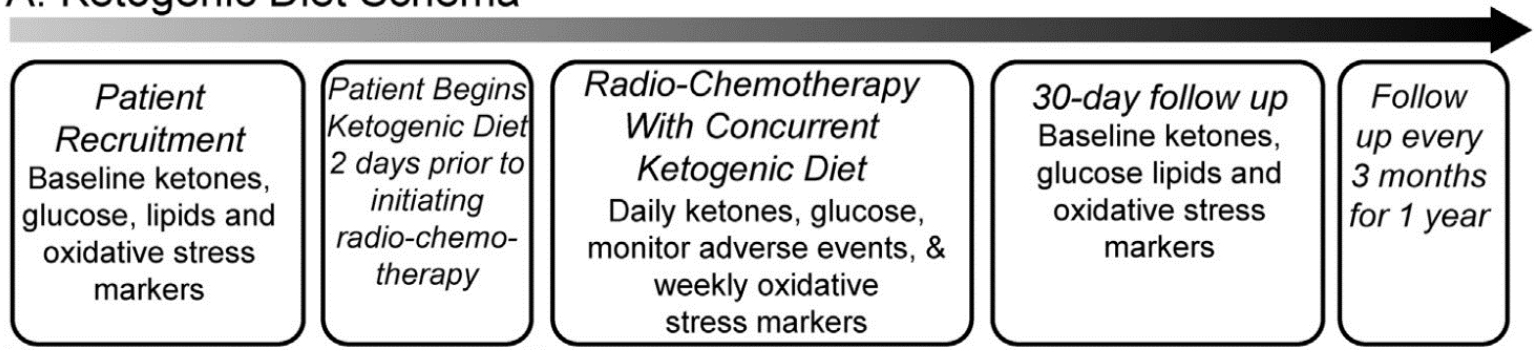
To convert a glucose measurement in mg/dl to mmol, divide it by 18

SEYFRIED 指数

从大脑和肌肉的最佳能量供应流来看，1-3 mM为正常营养性生酮过程。

生酮饮食方案示例

A. Ketogenic Diet Schema



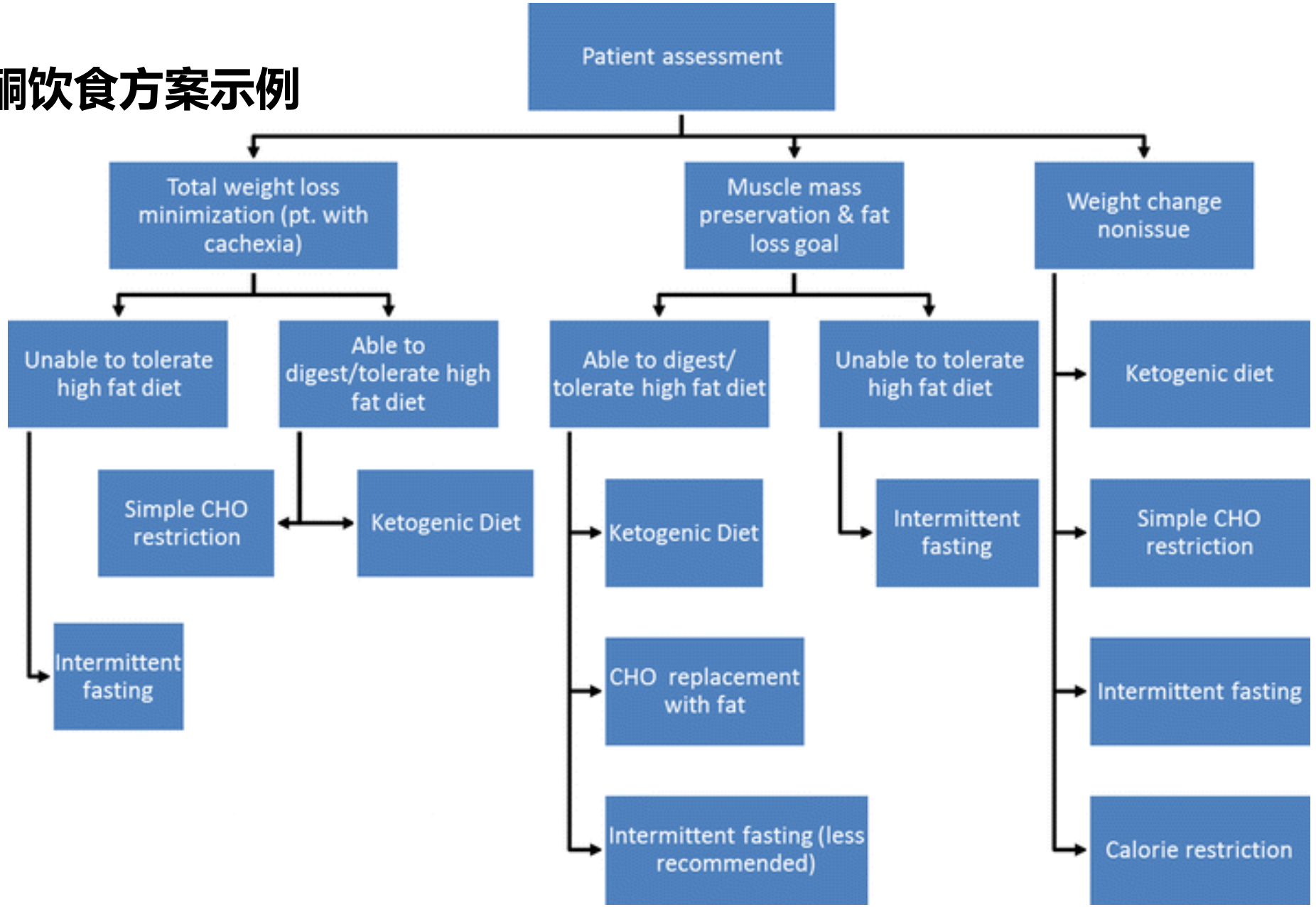
B. Typical Ketogenic Diet Plan

Course	Example	Energy, kcal	Fat, g	Protein, g	Carbohydrates, g
Breakfast	Crêpes Carb-free hot cocoa	555	54.8	11.0	2.7
Lunch	Bun-less hamburger with mustard mayo dip Chocolate frosted cupcake Low-carb milk	550	53.7	11.1	3.7
Snack	Pineapple keto-cal shake	525	52.6	11.0	2.4
Dinner	Taco salad Low-carb milk	760	75.7	15.1	3.2
Total *(% daily energy)*		2390	236.8 (90%)	48.2 (8%)	12.0 (2%)

(A) 癌症患者一期临床生酮饮食方案 (B)生酮饮食的举例。

BG. Allen et al. ***Redox Biology***, 2016

生酮饮食方案示例



Rainer J. Klement, et al. *Cancer and Metastasis Reviews*,2014

正在进行的生酮饮食治疗肿瘤的临床试验

Condition	Intervention	Identifier
Pancreatic Neoplasms	Ketogenic diet with concurrent chemoradiation	NCT01419483
Head and Neck Neoplasms	Ketogenic diet with concurrent chemoradiation	NCT01975766
Carcinoma, NonSmall-Cell Lung	Ketogenic diet with concurrent chemoradiation	NCT01419587
Glioblastoma	Energy-restricted ketogenic Diet	NCT01535911
Breast Cancer	Ketogenic diet, low glycaemic and insulinaemic diet	NCT02092753
Glioblastoma Multiforme	Ketogenic diet	NCT01865162
Cancer	Ketogenic diet	NCT01716468
Recurrent Glioblastoma	Calorie-restricted ketogenic diet and transient fasting with concurrent radiation	NCT01754350
Glioblastoma	Ketogenic diet with concurrent chemoradiation	NCT02046187

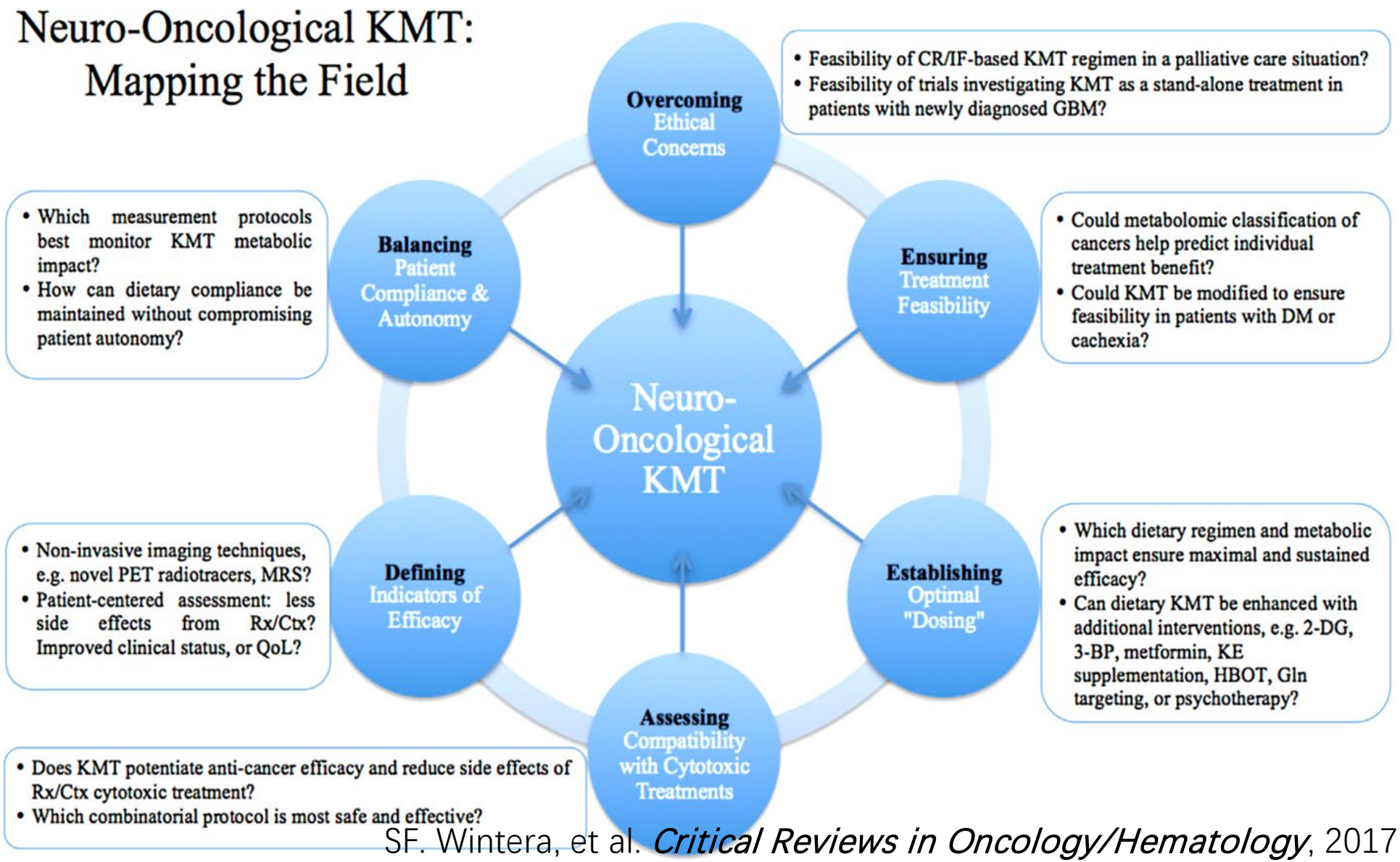
目前有多项生酮饮食疗法在神经胶质母细胞瘤、乳腺癌、非小细胞肺癌、头颈癌、胰腺癌上进行试验。

AF. Branco et al. *European Journal of Clinical Investigation*, 2016

生酮饮食治疗肿瘤的临床试验

- Nebeling LC, *et al*. Effects of a ketogenic diet on tumor metabolism and nutritional status in pediatric oncology patients: two case reports. J Am Coll Nutr, 1995;14:202-208.
- Zuccoli G, *et al*. Metabolic management of glioblastoma multiforme using standard therapy together with a restricted ketogenic diet: Case Report. Nutr Metab (Lond) 2010;7:33.
- Fine EJ, *et al*. Targeting insulin inhibition as a metabolic therapy in advanced cancer: A pilot safety and feasibility dietary trial in 10 patients. Nutrition 2012;28:1028-1035.
- Schwartz K, *et al*. Treatment of glioma patients with ketogenic diets: report of two cases treated with an IRB-approved energy-restricted ketogenic diet protocol and review of the literature. Cancer Metab. 2015 Mar 25;3:3.
- Champ CE, *et al*. Targeting metabolism with a ketogenic diet during the treatment of glioblastoma multiforme. J Neurooncol. 2014 Mar;117(1):125-31.
- Jansen N, Walach H. The development of tumours under a ketogenic diet in association with the novel tumour marker TKTL1: A case series in general practice. Oncol Lett. 2016;11(1):584-592.

生酮治疗在神经胶质瘤中的研究前景



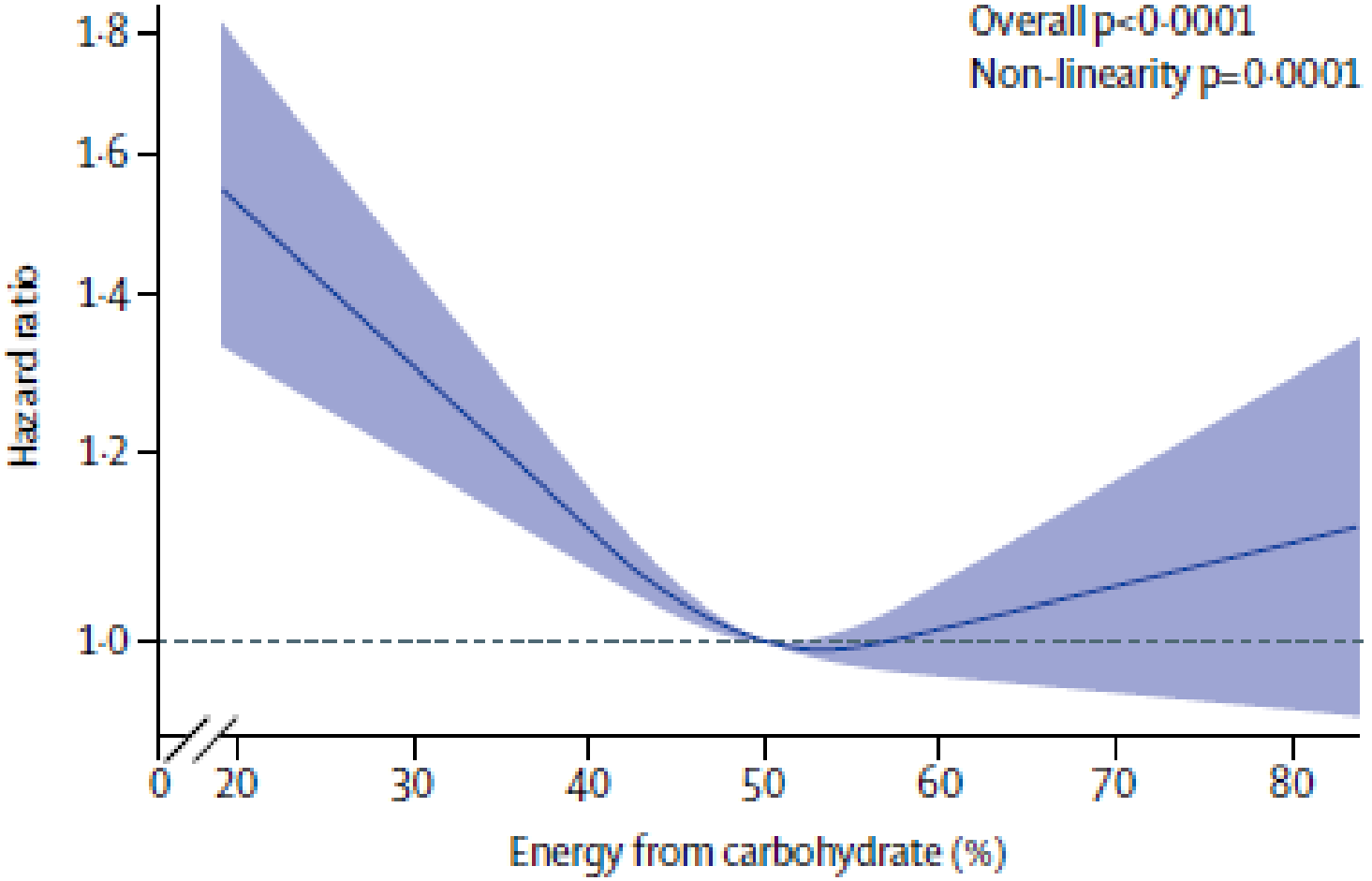
SF. Wintera, et al. *Critical Reviews in Oncology/Hematology*, 2017

Abbreviations: 2-DG= 2-deoxyglucose; 3-BP= 3-bromopyruvate; CR= caloric restriction; Ctx= chemotherapy; DM= diabetes mellitus; GBM= glioblastoma multiforme; Gln= Glutamine; HBOT= hyperbaric oxygen therapy; IF= intermittent fasting; KE= ketone ester; KMT= ketogenic metabolic therapy; MRS= magnetic resonance spectroscopy; PET= positron emission tomography; QoL= quality of life; Rx= radiotherapy

警告

生酮饮食/低碳水饮食/轻断食必须在医师/营养师的指导下进行

在没有取得大型流行病研究结论之前，生酮饮食只能定位为一种治疗性饮食。目的达成后必须转换为均衡饮食/地中海饮食。



Seidelmann, Sara B et al.Dietary carbohydrate intake and mortality: a prospective cohort study and meta-analysis.The Lancet Public Health , Volume 0 , Issue 0 ,

谢 谢