

Cardiac remodeling in obesity and after bariatric and metabolic surgery; is there a role for gastro-intestinal hormones

Authors

Elijah Sanches, MD¹; Marieke Timmermans, MD¹ ; Besir Topal, MD²; Alper Celik, MD, PhD³ ; Magnus Sundbom, MD, PhD⁴ ; Rui Ribeiro, MD⁵; Chetan Parmer MS, DNB, FRCS⁶; Surendra Ugale MD, PhD⁷; Monika Proczko, MD⁸; Pieter S. Stepaniak PhD⁹; Juan Pujol Rafols MD¹⁰; Kamal Mahawar, MS, MSc, FRCS¹¹; Marc P. Buise, MD, PhD¹²; Aleksandr Neimark MD¹³; Rich Severin PT, DPT, CCS^{14,15}; Sjaak Pouwels, MD, PhD¹⁶

Affiliations

1. Department of Surgery, Haaglanden Medical Center, The Hague, The Netherlands
2. Department of Cardiothoracic Surgery, Onze Lieve Vrouwe Gasthuis, Amsterdam, The Netherlands
3. Metabolic Surgery Clinic, Sisli, Istanbul, Turkey
4. Department of Surgical Sciences, Uppsala University, Uppsala, Sweden
5. Centro Multidisciplinar da Doença Metabólica, Clínica de Santo António, Reboleira, Lisbon, Portugal
6. Department of Surgery, Whittington Hospital, London, UK
7. Bariatric & Metabolic Surgery Clinic, Kirloskar Hospital, Hyderabad, India
8. Department of General, Endocrine and Transplant Surgery, University Medical Center, Gdansk University, Gdansk, Poland
9. Department of Operating Rooms, Catharina Hospital, Eindhoven, The Netherlands
10. Department of Surgery, Clinica Mi Tres Torres, Barcelona, Spain
11. Bariatric Unit, Sunderland Royal Hospital, Sunderland, United Kingdom
12. Department of Anesthesiology, Intensive Care and Pain Medicine, Catharina Hospital, Eindhoven, The Netherlands
13. Department of Surgery, Almazov National Medical Research Centre, Saint Petersburg, Russia
14. Department of Physical Therapy, College of Applied Health Sciences, University of Illinois at Chicago, Chicago, IL, USA;
15. Doctor of Physical Therapy Program, Robbins College of Health and Human Sciences, Baylor University, Waco, TX, USA
16. Department of Intensive Care Medicine, Elisabeth-Tweesteden Hospital, Tilburg, The Netherlands

Background

Obesity is associated with various diseases such as type 2 diabetes, hypertension, obstructive sleep apnea syndrome (OSAS), metabolic syndrome, and cardiovascular diseases. It affects several organ systems, including the pulmonary and cardiac systems. Furthermore, it induces pulmonary and cardiac changes that can result in right and/or left heart failure.

Methods

In this review, authors provide an overview of obesity and cardiovascular remodeling, the individual actions of the gut hormones (like GLP-1 and PYY), the effects after bariatric/metabolic surgery and its influence on cardiac remodeling. In this review, we focussed and searched for literature in Pubmed and The Cochrane library (from the earliest date until April 2019), regarding cardiac function changes before and after bariatric surgery and literature regarding changes in gastrointestinal hormones

Conclusion

Regarding the surgical treatment of obesity and metabolic diseases there is recognition of the importance of both weight loss (bariatric surgery) and improvement in metabolic milieu (metabolic surgery). A growing body of evidence further suggests that bariatric surgical procedures [like the Sleeve Gastrectomy (SG), Roux-en Y Gastric Bypass (RYGB), or One Anastomosis Gastric Bypass (OAGB)] have can improve outcomes of patients suffering from a number of cardiovascular diseases, including heart failure.

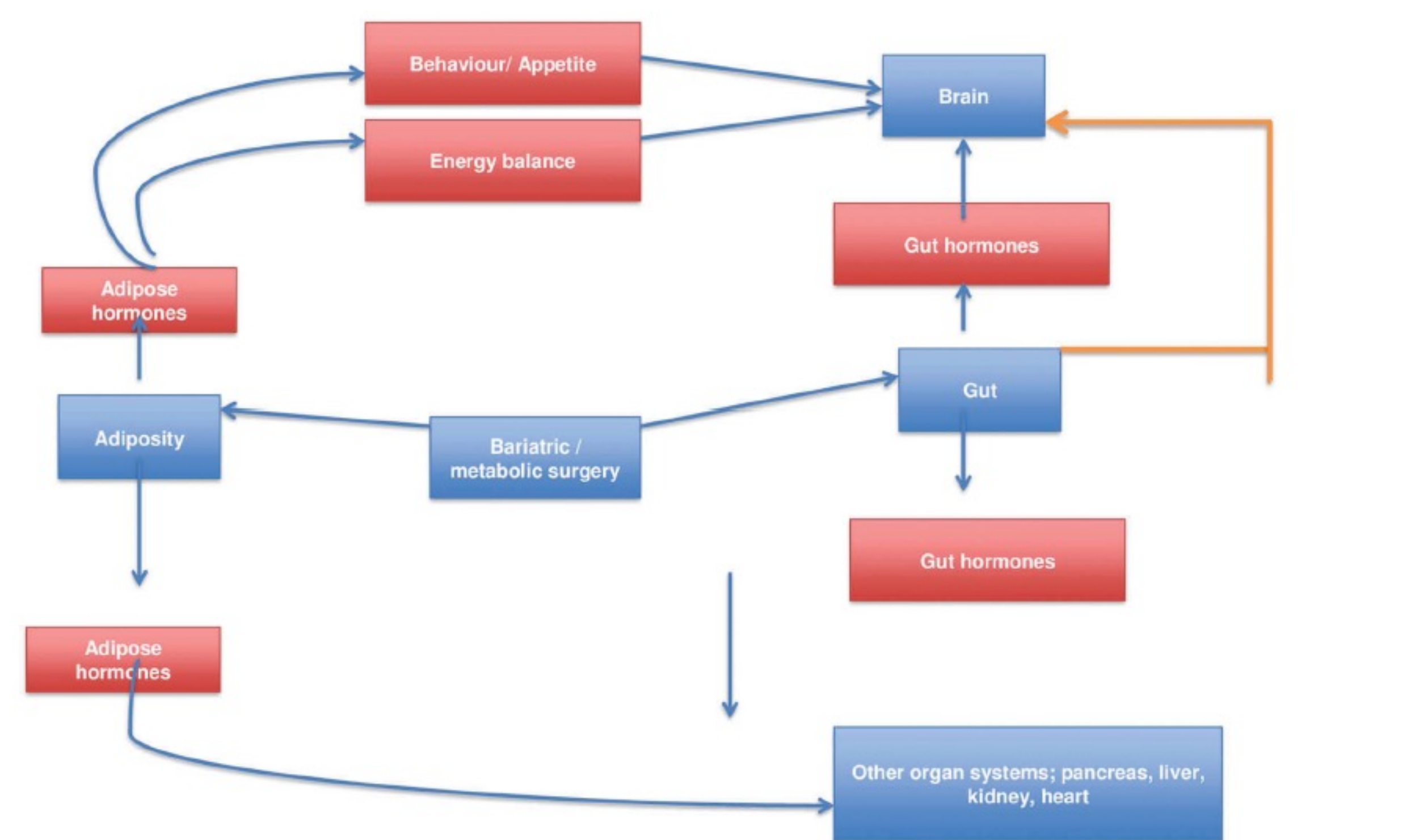


Figure 2. Overview of the mechanisms of gastrointestinal hormones and its interaction with the brain/appetite regulation (the orange line represents the vagus nerve).

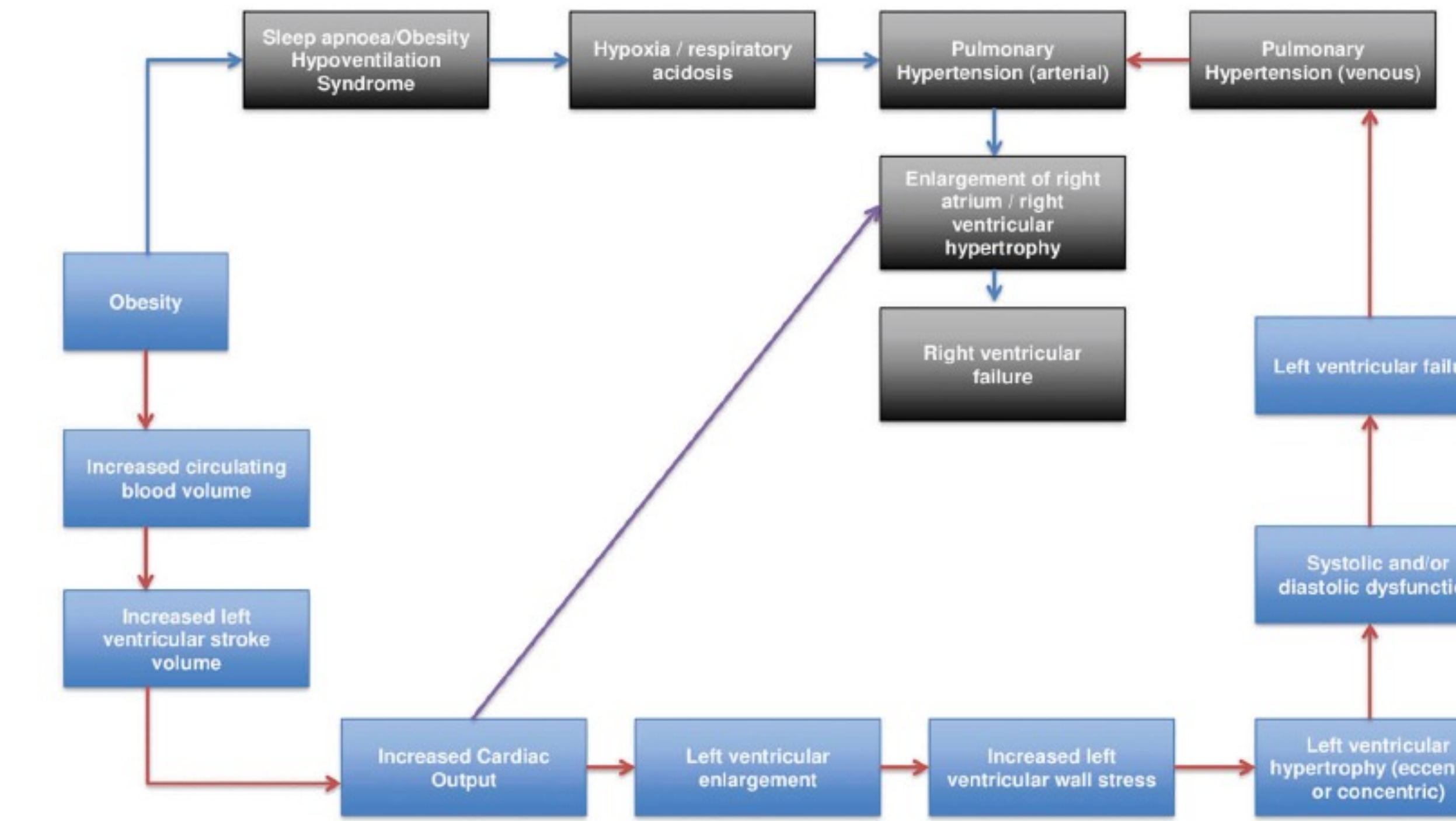


Figure 3. Functional changes in cardiac structure and function due to obesity (Adapted from Lascais et al. [153] and Aggarwal et al. [14]).

Table 1. Effects of bariatric and metabolic surgery on GLP-1 and PYY.

Study	Surgical procedure	Number of subjects (N)	Follow-up	Increase	Decrease	No change
GLP-1						
Naslund et al. 1997 [121]	JIB	7	6-12 months	Yes	-	-
Naslund et al. 1998 [122]	JIB	12	9 months – 20 years	Yes	-	-
Cigaina et al. 2003 [170]	Gastric Pacing	11	6 months	-	Yes	-
Rubino et al. 2004 [183]	RYGB	10	3 weeks	-	-	Yes
Lugari et al. 2004 [120]	BPD	22	50% Excess weight reduction	Yes	-	-
Clements et al. 2004 [184]	RYGB	20	3 months	-	-	Yes
Korner et al. 2005 [123]	RYGB	12	30 – 40 months	Yes	-	-
Valverde et al. 2005 [169]	VBG	12	6 months	-	-	Yes
Valverde et al. 2005 [169]	BPD	19	6 months	Yes	-	-
Morinigo et al. 2006 [124]	RYGB	9	6 weeks	Yes	-	-
Morinigo et al. 2006 [124]	RYGB	34	12 months	Yes	-	-
Borg et al. 2006 [125]	RYGB	6	6 months	Yes	-	-
Guidone et al. 2006 [185]	BPD	10	1-4 weeks	Yes	-	-
Santoro et al. 2006 [126]	DAIR	55	12-34 months	Yes	-	-
Le Roux et al. 2007 [91]	RYGB	16	42 days	Yes	-	-
Laferrere et al. 2007 [127]	RYGB	8	1 month	Yes	-	-
Whitson et al. 2007 [180]	RYGB	10	6 months	Yes	-	-
Reinhr et al. 2007 [128]	GB	11	24 months	-	Yes	-
Reinhr et al. 2007 [128]	RYGB	19	24 months	-	Yes	-
Korner et al. 2007 [168]	GB	10	180 min	-	-	Yes
Korner et al. 2007 [168]	RYGB	13	180 min	Yes	-	-
Laferrere et al. 2008 [179]	RYGB	9	1 month	Yes	-	-
Shak et al. 2008 [167]	GB	24	6-12 months	-	-	Yes
Santoro et al. 2008 [129]	DAIR	228	12-60 months	Yes	-	-
Rodieux et al. 2008 [130]	RYGB	8	9-48 months	Yes	-	-
Heap et al. 2008 [131]	Heap procedure	246	2 months	Yes	-	-
Salinari et al. 2008 [186]	BPD	9	1 month	Yes	-	-
Vidal et al. 2008 [132]	RYGB	24	>36 months	Yes	-	-
De Carvalho et al. 2009 [133]	RYGB	19	9 months	Yes	-	-
PYY						
Naslund et al. 1997 [121]	JIB	7	6-12 months	Yes	-	-
Alvarez Bartolomé et al. [134]	VBG	12	12 months	Yes	-	-
Morinigo et al. 2006 [124]	RYGB	9	6 weeks	Yes	-	-
Korner et al. 2006 [221]	GB	9	180 min	-	-	Yes
Korner et al. 2006 [221]	RYGB	9	180 min	Yes	-	-
Chan et al. 2006 [135]	RYGB	6	10-26 months	Yes	-	-
Stratis et al. 2006 [136]	BPD-RYGB	20	12 months	Yes	-	-
Santoro et al. 2006 [126]	DAIR	55	12-34 months	Yes	-	-
Le Roux et al. 2006 [90]	GB	6	6-36 months	-	-	Yes
Le Roux et al. 2006 [90]	RYGB	6	6-36 months	Yes	-	-
Le Roux et al. 2007 [91]	RYGB	16	42 days	Yes	-	-
Reinhr et al. 2007 [128]	GB	11	24 months	Yes	-	-
Reinhr et al. 2007 [128]	RYGB	19	24 months	Yes	-	-
Santoro et al. 2008 [129]	DAIR	228	12-60 months	Yes	-	-
Rodieux et al. 2008 [130]	RYGB	8	9-48 months	Yes	-	-
Heap et al. 2008 [131]	Heap procedure	246	2 months	Yes	-	-
Karamanikos et al. 2008 [137]	RYGB+SG	16	12 months	Yes	-	-
García-Fuentes et al. 2008 [138]	BPD	38	7 months	Yes	-	-
García-Fuentes et al. 2008 [138]	RYGB	13	7 months	Yes	-	-

Abbreviations: RYGB = Roux-en-Y Gastric Bypass; BPD = Biliopancreatic diversion; VBG = Vertical Banded Gastroplasty; GB = Gastric Band; SG = Sleeve Gastrectomy; DAIR; Digestive Adaptation with Intestinal Reserve.

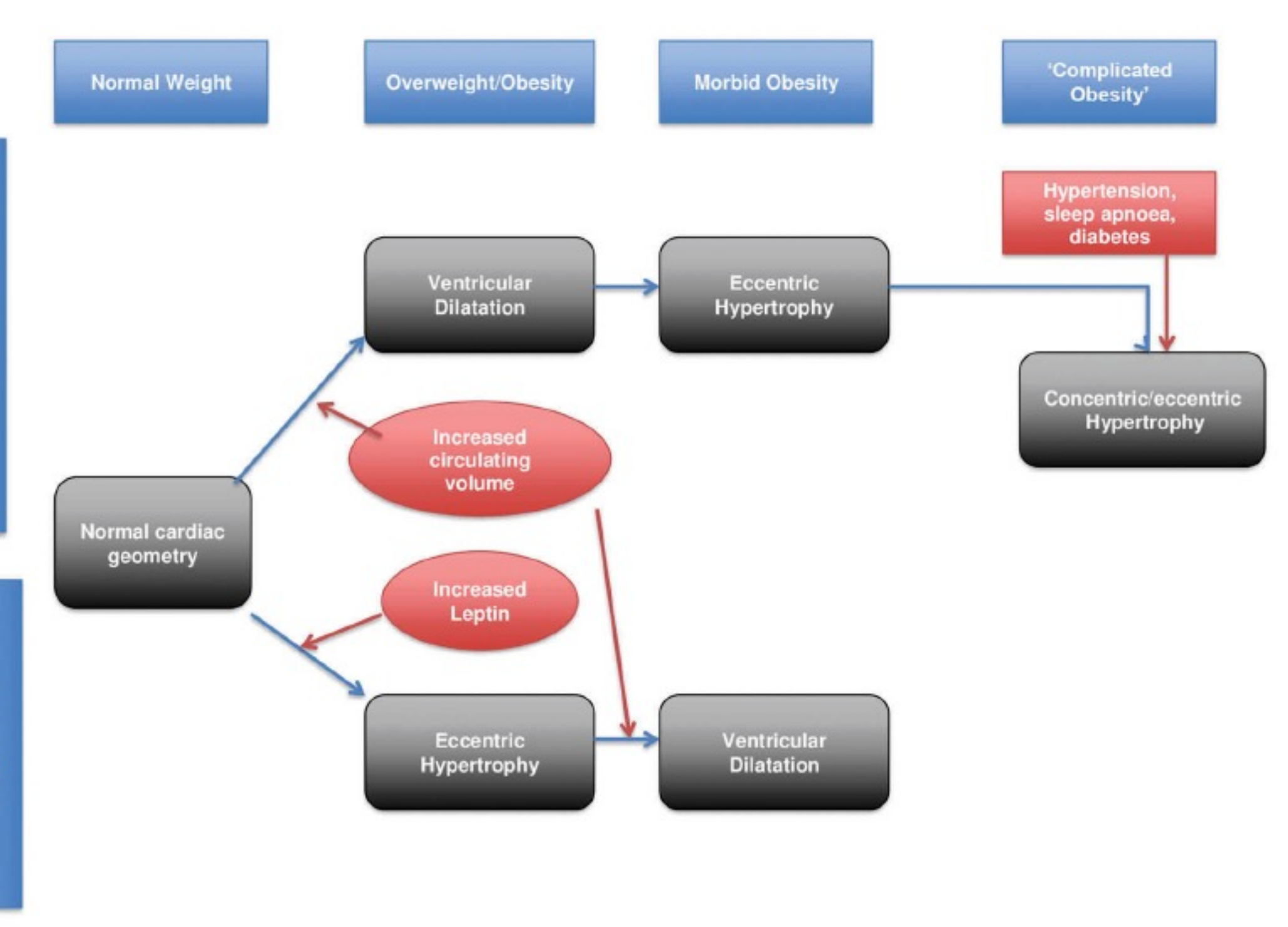


Figure 4. Current metabolic and hemodynamic hypotheses regarding physiology in cardiac structure and hemodynamic changes.

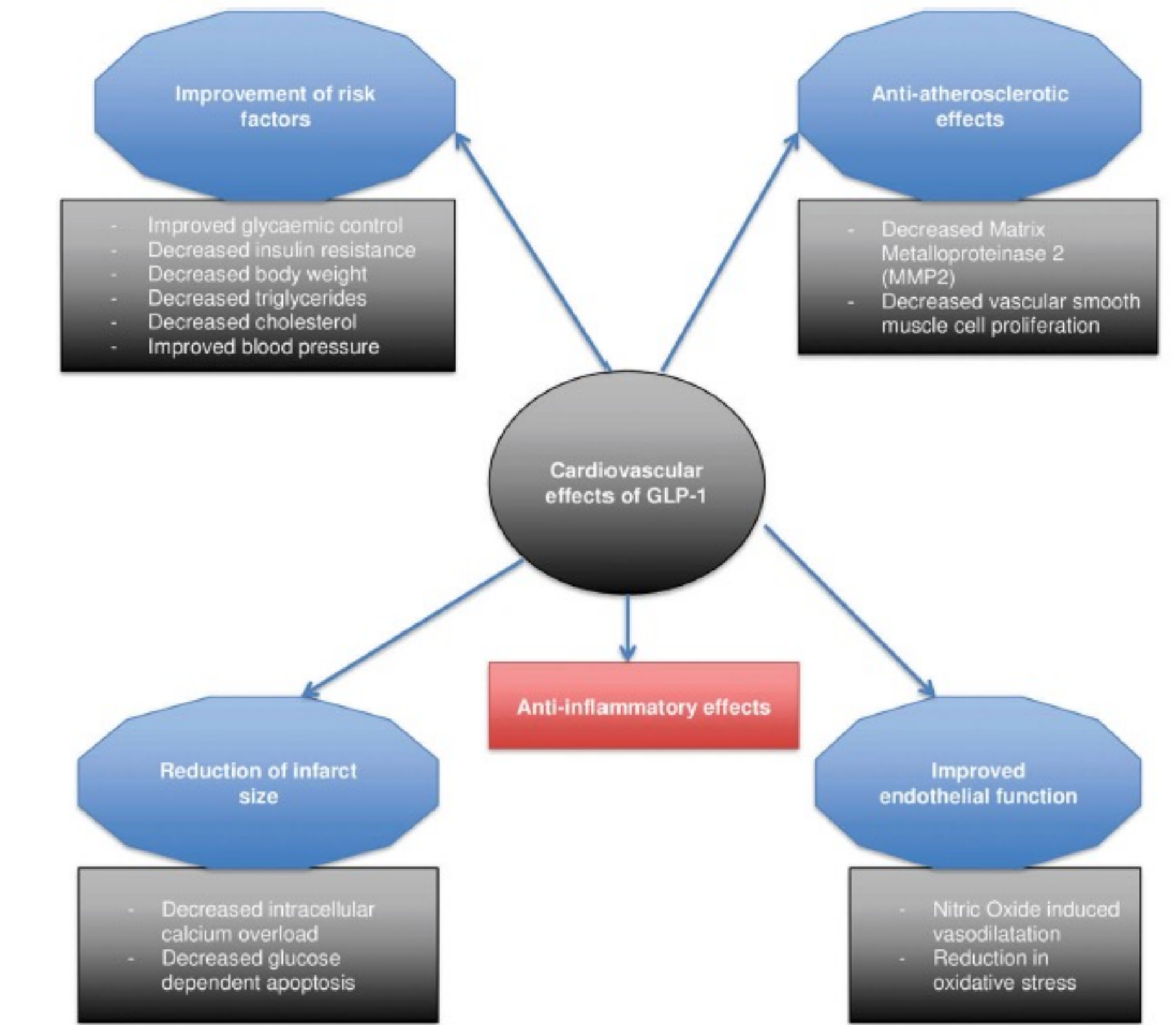


Figure 5. Direct and indirect effects of GLP-1 (and GLP-1 receptor agonists) on cardiovascular physiology.

Table 2. Effects of bariatric and metabolic surgery on Ghrelin.

Study	Surgical procedure	Number of subjects (N)	Follow-up	Increase	Decrease	No change
Bypass procedures						
Cummings et al. 2002 [189]	RYGB	5	9-31 months	-	Yes	-
Holdstock et al. 2003 [192]	RYGB	10	12 months	Yes	-	-
Leonetti et al. 2003 [193]	RYGB	11	9-15 months	-	-	Yes
Faraj et al. 2003 [194]	RYGB	50	9-21 months	Yes	-	-
Tritos et al. 2003 [195]	RYGB	6	10-26 months	-	Yes	-
Adami et al. 2003 [196]	BPD	15	2 months	-	-	Yes
Lin et al. 2004 [197]	RYGB	34	10 min	-	Yes	-
Vendrell et al. 2004 [278]	RYGB	34	6 months	Yes	-	-
Fruhbeck et al. 2004 [198]	RYGB	15	24 hours	-	Yes	-
Fruhbeck et al. 2004 [199]	RYGB	6	6 months	-	Yes	-
Fruhbeck et al. 2004 [199]	BPD	3	4 months	-	Yes	-
Fruhbeck et al. 2004 [200]	RYGB	8	6 months	-	Yes	-
Adami et al. 2004 [201]	BPD	24	12 months	Yes	-	-
Stoedli et al. 2004 [202]	RYGB	5	24 months	-	-	Yes
Morinigo et al. 2004 [203]	RYGB	8	6 weeks	-	-	Yes
García-Unzueta et al. 2005 [204]	BPD	30	12 months	Yes	-	-
Korner et al. 2005 [123]	RYGB	12	30-40 months	-	-	Yes
Mingrone et al. 2006 [205]	BPD	6	14 days	Yes	-	-
Korner et al. 2006 [221]	RYGB	9	180 min	-	-	Yes
Chan et al. 2006 [135]	RYGB	6	10-26 months	-	Yes	-
Kotidis et al. 2006 [206]	BPD-DS	13	18 months	-	Yes	-
Stratis et al. 2006 [136]	BPD-RYGB	20	12 months	-	-	Yes
Couce et al. 2006 [207]	RYGB	49	6 months	-	-	Yes
Santoro et al. 2006 [126]	DAIR	55	12-34 months	-	Yes	-
Santoro et al. 2006 [126]	DAIR	100	10-26 months	-	-	Yes
Kotidis et al. 2006 [206]	BPD-DS	13	18 months	-	Yes	-
Le Roux et al. 2006 [90]	RYGB	6	6-36 months	-	-	Yes
Valera Mora et al. 2007 [210]	BPD	11	18 months	Yes	-	-
Sundbom et al. 2007 [143]	RYGB	15	12 months	Yes	-	-
Le Roux et al. 2007 [91]	RYGB	16	42 days	-	-	Yes
Whitson et al. 2007 [180]	RYGB	10	6 months	-	-	Yes
Liou et al. 2008 [277]	Mini RYGB	68	12 months	-	-	Yes
Santoro et al. 2008 [129]	DAIR	228	12-60 months	-	Yes	-
Rodieux et al. 2008 [130]	RYGB	8	9-48 months	-	Yes	-
Foschi et al. 2008 [211]	RYGB	10	7 months	Yes	-	-
Karamanikos et al. 2008 [137]	RYGB+SG	16	12 months	-	Yes	-
Heap et al. 2008 [131]	Heap Procedure	246	2 months	Yes	-	-
García-Fuentes et al. 2008 [138]	BPD	38	7 months	-	-	Yes
García-Fuentes et al. 2008 [138]	RYGB	13	7 months	Yes	-	-
García de la Torre et al. 2008 [212]	BPD	11	9-12 months	-	Yes	-
García de la Torre et al. 2008 [212]	RYGB	17	9-12 months	-	Yes	-
Pardina et al. 2009 [213]	RYGB	34	12 months	Yes	-	-
Gastric Pacing and GB, VBG and SG surgery						
Leonetti et al. 2003 [193]	GB	10	9-15 months	-	-	Yes
Geloneze et al. 2003 [214]	VBG	28	12 months	-	-	Yes
Hanusch-Engerer et al. 2003 [215]	GB	12	12 months	-	-	Yes
Lin et al. 2004 [197]	VBG	4	10 min	-	-	Yes
Fruhbeck et al. 2004 [198]	GB	12	24 hours	Yes	-	-
Fruhbeck et al. 2004 [199]	GB	7	7 months	Yes	-	-
Fruhbeck et al. 2004 [200]	GB	8	6 months	Yes	-	-
Hanusch-Engerer et al. 2004 [220]	GB	18	12 months	Yes	-	-
Nijhuis et al. 2004 [231]	VBG	7	24 months	Yes	-	-
Nijhuis et al. 2004 [231]	GB	10	24 months	Yes	-	-
Schindler et al. 2004 [216]	GB	23	6 months	Yes	-	-
Stoedli et al. 2004 [202]	VBG	8	24 months	Yes	-	-
Foschi et al. 2005 [217]	VBG	7	12 months	Yes	-	-
Korner et al. 2006 [221]	GB	9	180 min	-	Yes	-
Kotidis et al. 2006 [206]	VBG	13	18 months	Yes	-	-
Le Roux et al. 2006 [90]	GB	6	6-36 months	-	-	Yes
Cigaina et al. 2007 [170]	Gastric Pacing	11	6 months	Yes	-	-
Shak et al. 2008 [167]	GB	24	6-12 months	-	-	Yes
Foschi et al. 2008 [211]	VBG	12	7 months	Yes	-	-
Wang et al. 2009 [218]	GB	15	24 months	Yes	-	-
Wang et al. 2009 [218]	SG	10	24 months	-	Yes	-
García de la Torre et al. 2008 [212]	VBG	17	9-12 months	-	Yes	-

Abbreviations: RYGB = Roux-en-Y Gastric Bypass; BPD = Biliopancreatic diversion; BPD-DS = Biliopancreatic diversion with Duodenal Switch; VBG = Vertical Banded Gastroplasty; GB = Gastric Band; SG = Sleeve Gastrectomy; DAIR; Digestive Adaptation with Intestinal Reserve.