Diyabet yönetiminde glisemi takip kriterlerinde yeni yöntemler; HbA1c ve Ötesi

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Endokrinoloji ve Metabolizma BD

Sunum Planı

Glukoz takip yöntemleri

Kılavuzlardaki yeri

Yeni yöntemler ve gelecek

Glisemik Kontrolün Değerlendirilmesi

HbA1c

- Glisemik kontrolün klinik yararını çalışmalarda gösterdiği için hedefler belirlenmiş ve klinik pratikte kullanılmaktadır

Sürekli Glukoz takibi (CGM)

- Özellikle tip 1 DM hastalarında tedavinin etkinliğini ve emniyetini takip, hipogliseminin önlenmesi için kullanılır

Kendi kendine glukoz takibi(SMBG)

- Özellikle insülin kullanan hastalarda doz ayarlaması için kullanılır

HbA1c ve Diğer ölçüm yöntemleri ne sıklıkla kullanılmalı

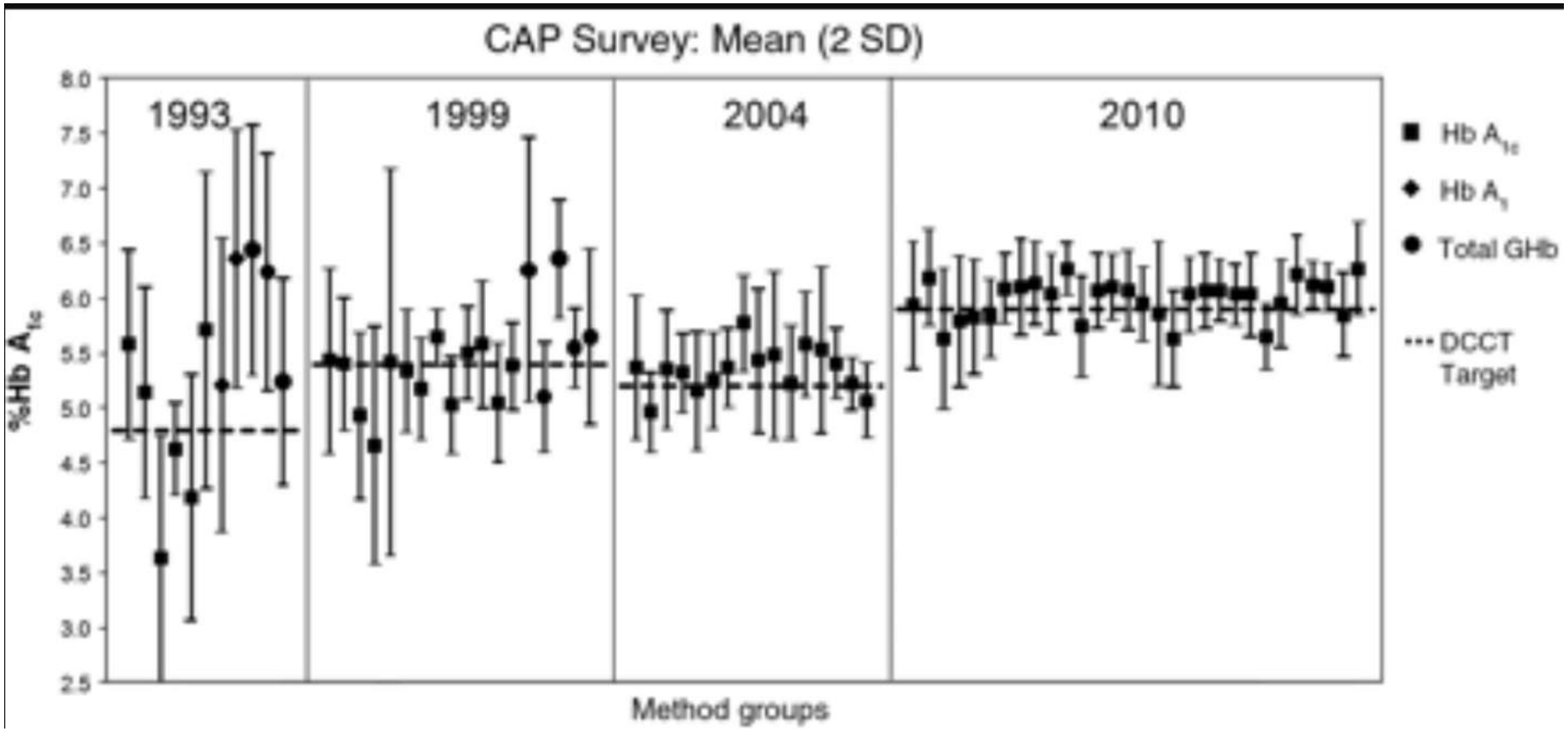
HbA1c ve diğer glukoz ölçüm yöntemleri tedavi hedeflerindeki hastalar için yılda en az 2 kez kullanılmalı

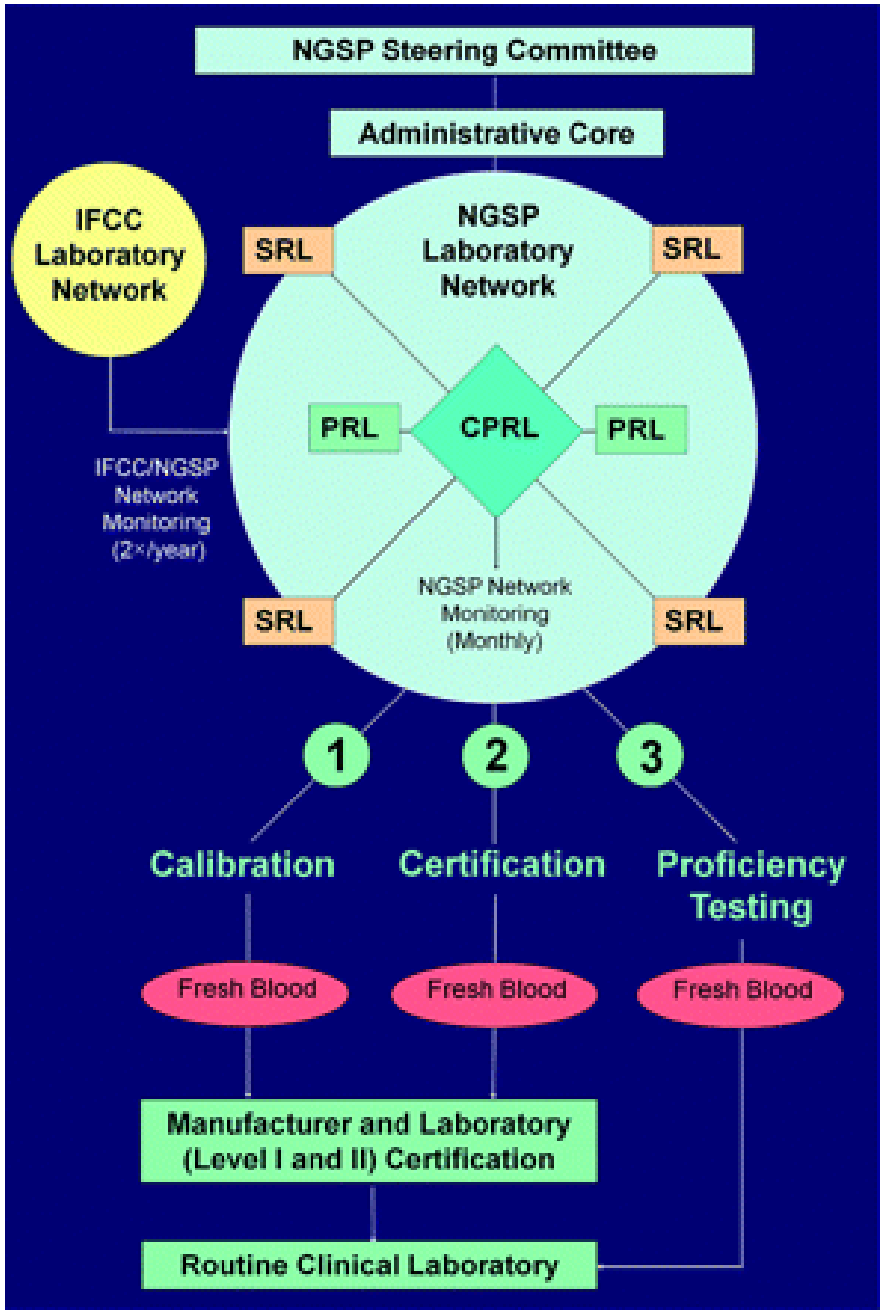
Tedavisi değiştirilen hastalarda, tedavi hedeflerine ulaşıncaya kadar ve stabilizasyon sağlanıncaya kadar yılda en az 4 kere ve ihtiyaç olduğu sürece

Kullanılan HbA1c

- National Glycohemoglobin Standardization Program (NGSP)-ile sertifiye edilmiş olmalı

Mean of each method compared to the NGSP/DCCT target (dotted line) in 1993, 1999, 2004, and 2010 based on CAP GH2 survey data. (USA)





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NIVERSITY PR

Fig. 1. NGSP network and process.

Clin Chem, Volume 57, Issue 2, 1 February 2011, Pages 205–214, https://doi.org/10.1373/clinchem.2010.148841

Veritabanı HbA1c birimleri

mmol/molHb
mg/dL
%6
ng/dL
4 - 5,9 %
mmol-mol(SI)
pg
pg/mL
K/µ
g/dL
µmol/L
&
NULL
% (*)
%
K/µ L

- mol/mol Hb
- % NGSP
- mmol/mol Hb
- IU/ml
- mmol/moll
- N/A
- SI
- mmol/mol Hb (SI)
- % (NGSP)
- %(NGSP)
- mmol/mol (*)
- aU/mL
- NGSP)
- mmol
- 10^3/µL
- g-dl
- sec^count^
- %(NHSP)
- % (NGSP)
- U/l

mmol/molhb
mg-dL
-
mmol/mol
mmol/moL
U/L
M/uL
umol/L
mmol/molHB
HbA1c
IU/mL
>=6,5
mmol/m
Diyabet.
4,51
% (NGSP/DC
%HbA1C
mUI/L
%
mL\dk
mM/M
hba1c
BIRIM

mmoL/moL
% (NGSP
KARAR
% HbA1c
mmol/moL
NULL
IU/l
ng/ml
mg/L
mlmol/mol
ug/dL
%
*<%5,7
mg/dl
m
ng/mL
(%)
g/dl
mmol/ mol
% THb
mmol/L
20 - 41 mmol/mol Hb
g-dL
mmol/mol
Diyabet

3.2
NGSP
KLİNİK
(NGSP)
g/L
fL
mmol / mol
%*
%mmol/L
% (NGSP/DCCT)
pg/ml
4.0- 6.0 %
mg-dl
mmol-mol
mmol-L
.
mmol/mol Hb
(SI)
mmol/gün
mmol/mol H
Normal
%6,1
% (NGSP)
mmol-mol Hb

Estimated average glucose (eAG)

A1C (%)	mg/dL*	mmol/L
5	97 (76–120)	5.4 (4.2–6.7)
6	126 (100–152)	7.0 (5.5–8.5)
7	154 (123–185)	8.6 (6.8–10.3)
8	183 (147–217)	10.2 (8.1–12.1)
9	212 (170–249)	11.8 (9.4–13.9)
10	240 (193–282)	13.4 (10.7–15.7)
11	269 (217–314)	14.9 (12.0–17.5)
12	298 (240–347)	16.5 (13.3–19.3)

Data in parentheses are 95% CI. A calculator for converting A1C results into eAG, in either mg/dL or mmol/L, is available at professional.diabetes.org/eAG.

* These estimates are based on ADAG data of ~2,700 glucose measurements over 3 months per A1C measurement in 507 adults with type 1, type 2, or no diabetes. The correlation between A1C and average glucose was 0.92 (6,7). Adapted from Nathan et al. (6).

HbA1c (Glikohemoglobin)

Önceki 4 ayın ortalama glukoz ölçümünün sonucunu verir,

HbA1c (%)	eAG (mg/dL)	eAG (mmol/l)
5	97	5.4
6	126	7.0
7	154	8.6
8	183	10.2
9	212	11.8
10	240	13.4
11	269	14.9
12	298	16.5

The relationship between eAG and HbA1c based on linear regression analysis was:eAG(mg/dl)= (28.7*HbA1c)-46.7, r2=0.84 (Diabetes Care 2008;31:1-6).

A1C sınırları

- Glisemik kontrolün dolaylı ölçümü,
- Değişkenliği az
- Eritrosit yaşam süresi (Hemolitik anemi, G6PD eksikliği, Kan nakli, Eritropoezi uyaran ilaçlar, Son dönem böbrek yetmezliği, gebelik) gerçek glukoz sonuçlarına göre farklı sonuçlar elde edilmesine neden olur.
- Hemoglobinopatiler; Heterozigot olanlarda fruktozamin ve1.5 anhidroglucitol kullanılabilir. Fakat prognostik durumları tam gösterilmemiştir
- A1c glisemik değişkenliği ve hipoglisemiyi göstermez,
- Tip 1DM ve insülonopenik Tip 2 hastalarda SMBG veya CGM A1c ile birlikte kullanılmalıdır.

Ülkemizde Bu konuda standart var mı?

- TİCK
- **Iso 15189 laboratuvar akreditasyonu standardına,** ilişkin profesyonel personelin tamamına yada bir kısmına, onların verimliliklerine ve bu kapsamdaki sorumluluklarına uygulanabilen kendine has mevzuat ve koşulları olduğu kabul edilmektedir. ISO 15189 standardı, ISO 17025 üzerine ilerletilmiş bir standart olup, özellikle tıbbi laboratuvar görevini açıklarken, ISO 17025 yalnız laboratuvar kalite yönetim ağındaki yetkinliğini tanımlamaktadır.

Glisemik Değerlendirme; Ambulatuvar Glukoz ile anlamlı ilişki

- Öğle Tokluk, Yatma öncesi
- 7 noktalı ölçüm
- HbA1c

A1C ; Etnik etki, Çocuklar, Hb varyantları

Genelde Glukoz ortalaması ile r (0.92)

Etnik farklılık yok

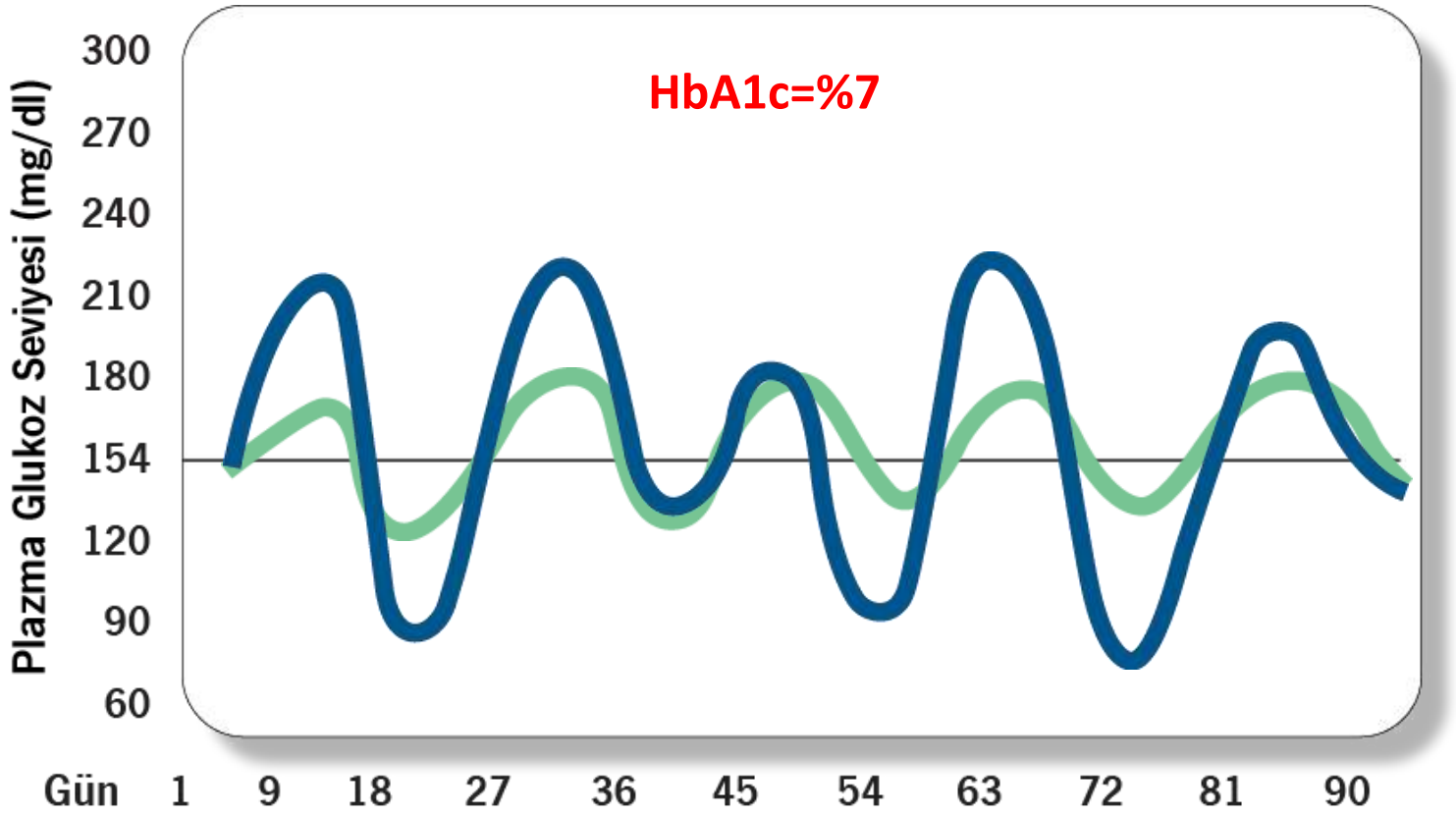
Afrikalılar ve African American olanlarda çalışmanın gücü düşük

HbS % 0.3 farklı sonuç

G6PD eksikliği; % 0.8-0.7 düşük ölçüm

Glukoz ortalaması ile karşılaştırıldığında çocuklarda r (0.7)

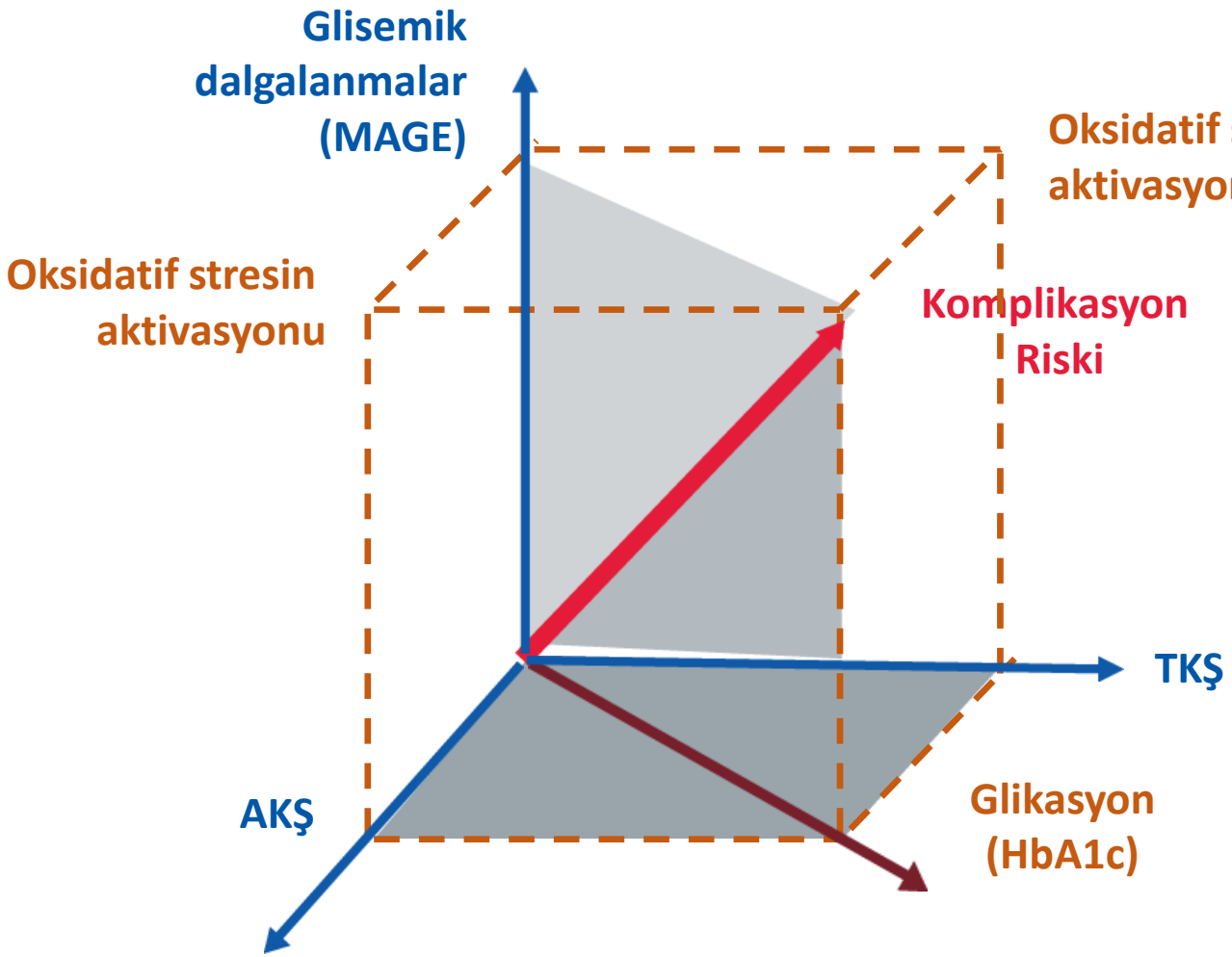
Aynı HbA1c düzeyine sahip 2 hasta farklı glisemik dalgalanma profili gösterebilir



Grafik 1 no'lu referanstan uyarlanmıştır.

1.Monnier L, Colette C. *Diabetes Care 2008;* 31 (Suppl. 2):S150–S154.

HbA1c'nin ötesinde glisemik kontrol



Hiperglisemiye neden olan 3 ana glisemik bozukluk vardır

Hiperglisemi nedeniyle 2 patolojik süreç aktive olur

Sonuç olarak komplikasyon riski artar

Glisemik dalgalanmalar kan glukoz düzeyinin açlık ve toklukta normal kabul edilen değerlerin üzerinde ve altında seyretmesi olarak tanımlanmaktadır.
MAGE: Glisemik dalgalanmaların ortalama büyüklüğü.
1.Monnier L, Colette C. *Diabetes Care 2008;* 31 (Suppl. 2):S150–S154.

CGM ile sürekli Glukoz Değerlendirilmesi

CGM lerden elde edilen ambulatuvar glikoz profili (AGP)

Tanımlanan aralıkta geçirilen süre (TIR); (Time in range)

Mikrovasküler komplikasyonlarla ilişkili

70 mg/dl altında geçirilen süre(Hedefin altında geçirilen süre)

54 mg/dl altında geçirilen süre(Hedefin altında geçirilen süre)

180 mg/dl üzerinde geçirilen süre(Hedefin üzerinde geçirilen süre)

AGP Report

Name

MRN

GLUCOSE STATISTICS AND TARGETS

14 days
% Sensor Time

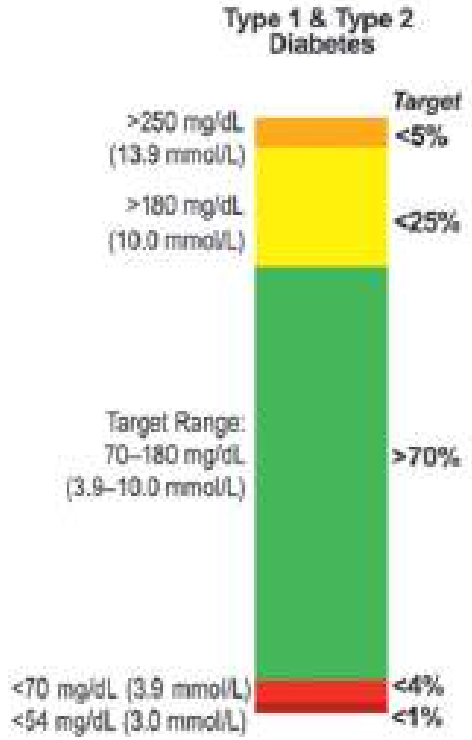
Glucose Ranges	Targets [% of Readings (Time/Day)]
Target Range 70–180 mg/dL	Greater than 70% (16h 48min)
Below 70 mg/dL	Less than 4% (58min)
Below 54 mg/dL	Less than 1% (14min)
Above 180 mg/dL	Less than 25% (6h)
Above 250 mg/dL	Less than 5% (1h 12min)

Each 5% increase in time in range (70–180 mg/dL) is clinically beneficial.

Average Glucose
Glucose Management Indicator (GMI)
Glucose Variability

Defined as percent coefficient of variation (%CV); target ≤36%

TIME IN RANGES



Glycemic Targets:
Standards of Medical Care in Diabetes - 2021. *Diabetes Care* 2021;44(Suppl. 1):S73-S84

Glisemik Hedefler

A1c hedefi: Gebe olmayan erişkinlerde hipoglisemik olmadan % 7 altında

Glikoz takip sistemlerinde hedeflenen aralıkta geçirilen süre zamanın % 70'nin üzerinde olmalı,

Hedeflenen aralığın altında geçirilen süre % 4'ün altında olmalı

Tip 1 Glisemik Kontrol

Seçilmiş kişiler için hipoglisemi olmadan A1C % 6.5 altında olmalı

Balayı döneminde daha düşük değerler hedeflenebilir

CGM: 14 günlük takipler tanımlanan aralıkta olmalı

Glukoz ölçüm yöntemlerinde Teknolojik gelişmeler

İn vivo ölçüm yöntemleri

- İnvaziv yöntemler
- İnvaziv olmayan yöntemler

İn vitro ölçüm yöntemleri

Glukoz Ölçüm Yöntemleri

- Ev/Hastane İzlemi
  - Kesikli
  - Sürekli

- **The use and efficacy of continuous glucose monitoring in type 1 diabetes treated with insulin pump therapy: a randomised controlled trial**
- T. Battelino & I. Conget & B. Olsen & I. Schütz-Fuhrmann & E. Hommel & R. Hoogma & U. Schierloh & N. Sulli & J. Bolinder & the SWITCH Study Group

- Received: 15 May **2012** / Accepted: 31 July 2012 / Published online: 11 September 2012 # The Author(s) 2012. This article is published with open access at Springerlink.co

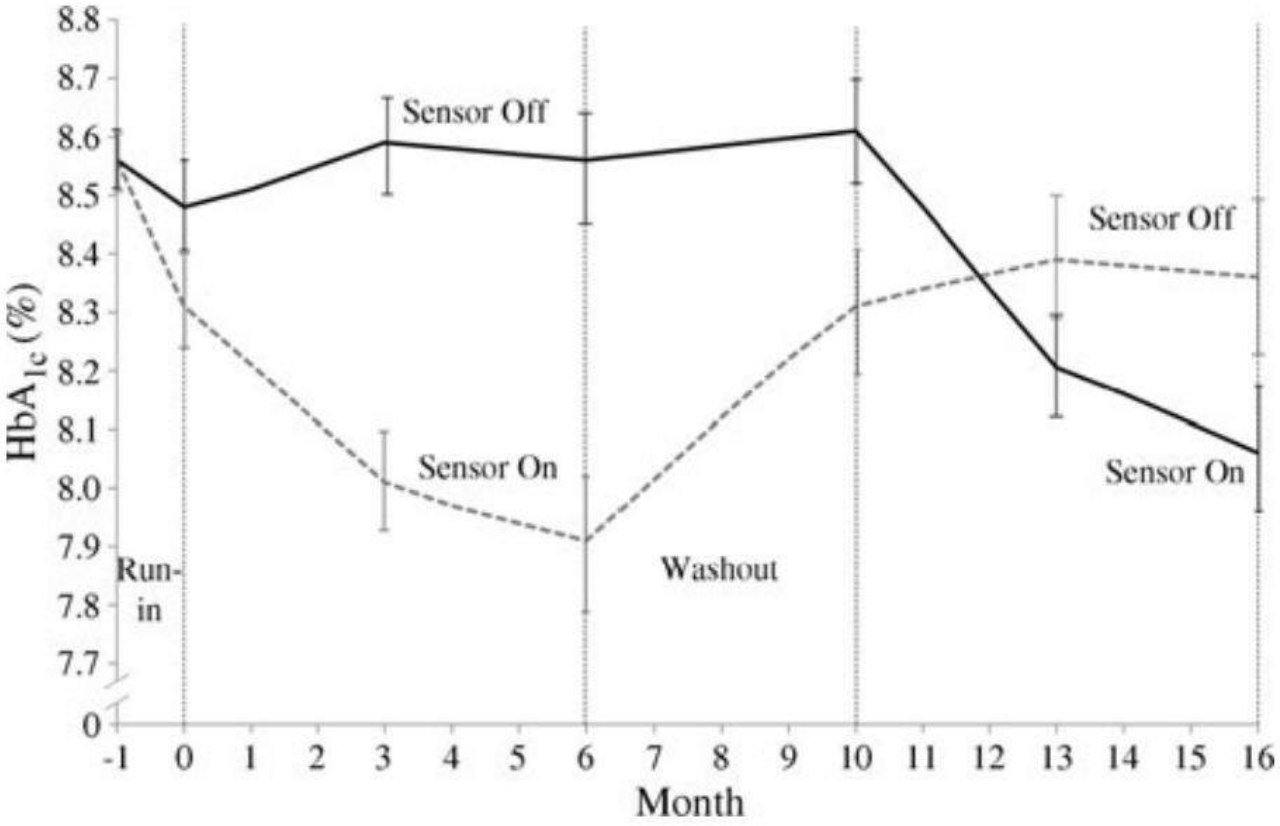


Fig. 2 Mean (±SEM) HbA_{1c} in participants randomised to Off/On (solid line) and On/Off (dashed line) sequences (all available observations): months −1 to 0: run in period; months 1 to 6: first period; months 7 to 10: washout; months 11–16: second period. To convert values for HbA_{1c} in % into mmol/mol, subtract 2.15 and multiply by 10.929

• Lancet Diabetes Endocrinol 2017; 5: 700–08

Effect of initiating use of an insulin pump in adults with type 1 diabetes using multiple daily insulin injections and continuous glucose monitoring (DIAMOND): a multicentre, randomised controlled trial

*Roy W Beck, Tonya D Riddlesworth, Katrina J Ruedy, Craig Kollman, Andrew J Ahmann, Richard M Bergenstal, Anuj Bhargava, Bruce W Bode, Stacie Haller, Davida F Kruger, Janet B McGill, William Polonsky, David Price, Elena Toschi, for the DIAMOND Study Group**

	Baseline*		Pooled follow-up*		Adjusted mean difference (95% or 99% CI)†‡	p value‡
	CGM plus CSII (n=37)	CGM plus MDI (n=38)	CGM plus CSII (n=36)	CGM plus MDI (n=36)		
Length of data, h	628 (576 to 648)	637 (618 to 655)	1702 (1515 to 1843)	1713 (1634–1776)	..	..
Time in range 70–180 mg/dL (3·9–10·0 mmol/L)						
Min per day	708 (162)	762 (224)	791 (157)	741 (225)	83 (17 to 149)	0·01
Proportion of day	49% (11)	53% (16)	55% (11)	51% (16)	6% (1 to 10)	0·01
Mean glucose concentration	..	..	..	..	..	0·005
mg/dL	185 (24)	178 (31)	172 (22)	182 (33)	−14 (−26 to −1)	..
mmol/L	10·3 (1·3)	9·9 (1·7)	9·5 (1·2)	10·1 (1·8)	−0·8 (−1·4 to −0·1)	..
Hyperglycaemia						
>180 mg/dL (>10·0 mmol/L), min per day	661 (557 to 836)	601 (467 to 793)	614 (455 to 694)	660 (457 to 823)	..	0·007
>250 mg/dL (>13·9 mmol/L), min per day	260 (176 to 371)	220 (105 to 309)	175 (120 to 274)	221 (115 to 299)	..	0·02
>300 mg/dL (>16·6 mmol/L), min per day	110 (56 to 165)	61 (25 to 104)	61 (30 to 102)	69 (32 to 109)	..	0·04
180 mg/dL (10·0 mmol/L), area under curve	32 (22 to 42)	25 (14 to 36)	22 (16 to 32)	27 (15 to 36)	..	0·02
Hypoglycaemia						
<70 mg/dL (<3·9 mmol/L), min per day	34 (25 to 58)	41 (23 to 75)	49 (34 to 79)	32 (15 to 51)	..	0·0001
<60 mg/dL (<3·3 mmol/L), min per day	14 (9 to 27)	16 (11 to 30)	23 (15 to 41)	12 (6 to 25)	..	0·0002
<50 mg/dL (<2·8 mmol/L), min per day	4 (2 to 10)	4 (2, 12)	9 (4 to 17)	4 (2 to 9)	..	0·0009
70 mg/dL (3·9 mmol/L), area above curve	0·25 (0·17 to 0·45)	0·28 (0·18 to 0·50)	0·39 (0·25 to 0·71)	0·21 (0·10 to 0·43)	..	0·0002
Coefficient of variation	39% (37% to 42%)	37% (35% to 42%)	39% (37% to 43%)	37% (33% to 39%)	..	0·25

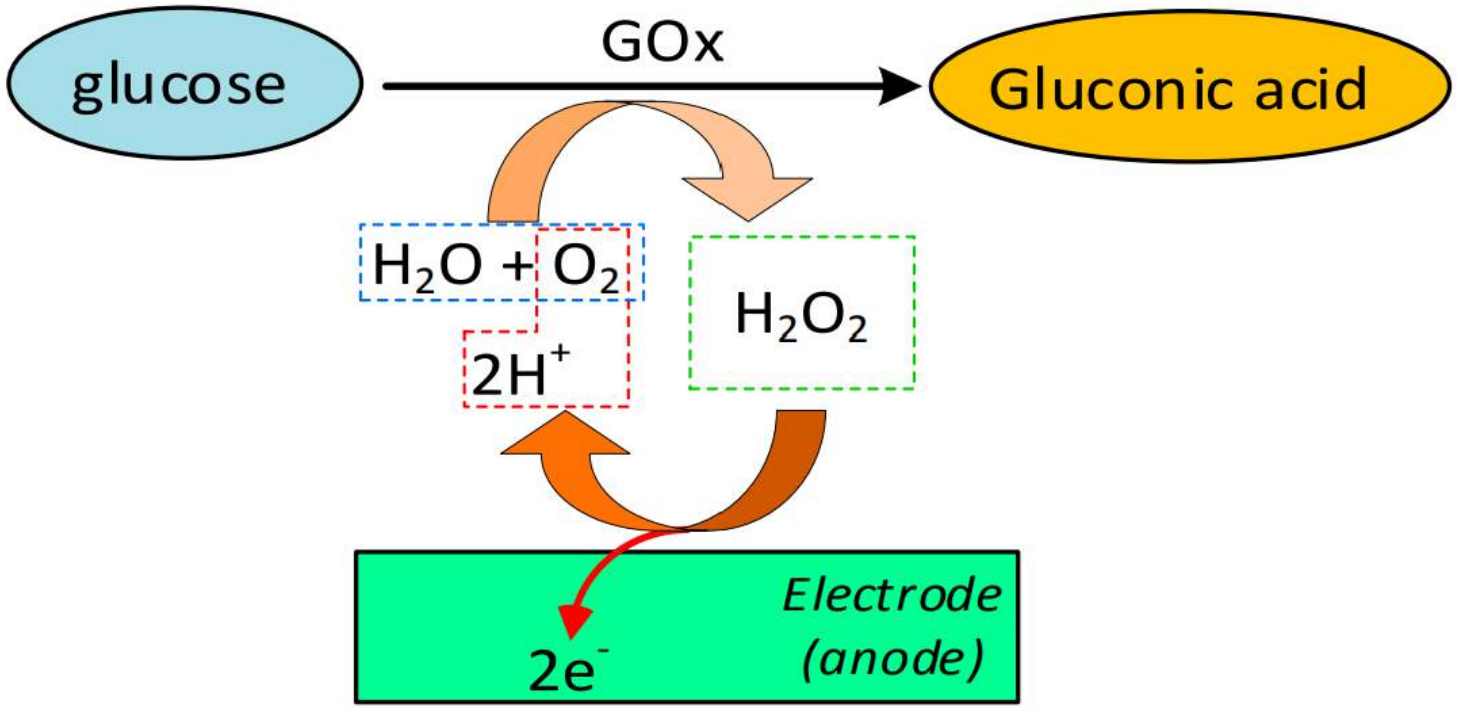
Data are median (IQR), mean (SD), or n (%), unless otherwise specified. 95% CI for the primary outcome of time in range and 99% CI for mean glucose. CGM=continuous glucose monitoring. CSII=continuous subcutaneous insulin infusion. MDI=multiple daily injections. *Baseline refers to time of randomisation for this trial; pooled follow-up combines all data collected in follow-up excluding the first 4 weeks for all participants randomly assigned, and excludes one participant in the CGM plus CSII group and two in the CGM plus MDI group with less than 72 h of follow-up data (none of whom completed the study). †95% CIs for the primary outcome; 99% CIs for mean glucose and all other secondary outcomes. ‡Treatment group comparisons based on linear regression models adjusted for the corresponding baseline value, baseline HbA_{1c}, and clinical site as a random effect; because of skewed distributions, the models for the hyperglycaemia, hypoglycaemia, and coefficient of variation are based on ranks using van der Waerden scores.

***Table 3*: CGM outcome metrics**

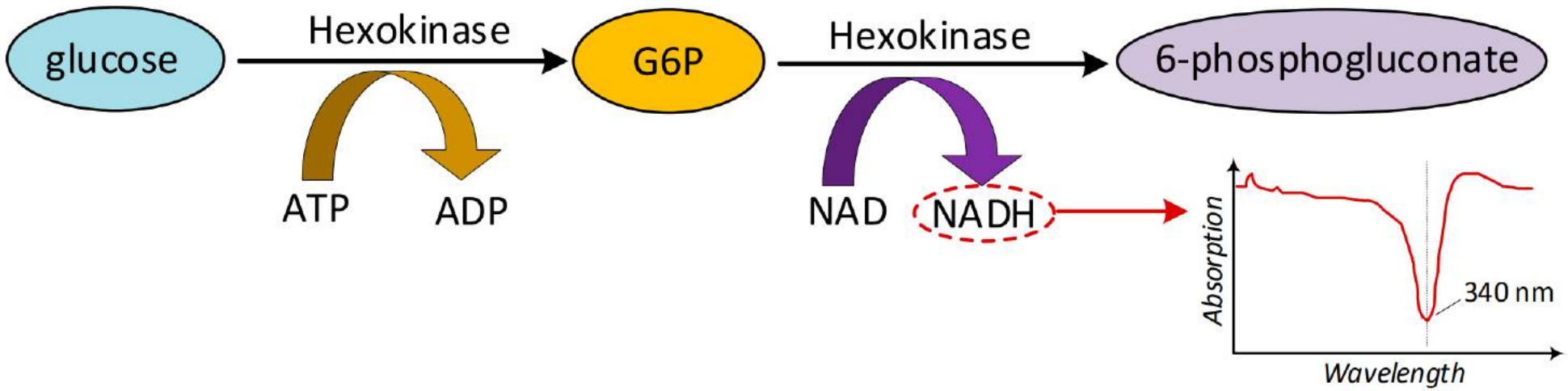
Laboratuvar Glukoz ölçümleri

Method	Equipment	Intended Use	Sample Type	Range	Ref.
Enzymatic	YSI 2700	Laboratory Point-of-care	• Blood • Plasma • Serum • CSF	0–2500 mg/dL	[14]
	YSI 2950D	Laboratory		5–2500 mg/dL	[15]
	Biosen C-Line/S-Line	Laboratory Point-of-care	• Blood • Plasma • Serum	9–900 mg/dL	[16]
Hexokinase	Beckman Coulter DxC 800	Laboratory	• Plasma • Serum • Urine • CSF	5–700 mg/dL	[17]
	Abbott ARCHITECT c8000/c16000			1–800 mg/dL	[18]
	Hitachi 917			2–750 mg/dL	[18]
	Cobas c 701/702			2–750 mg/dL	[19]

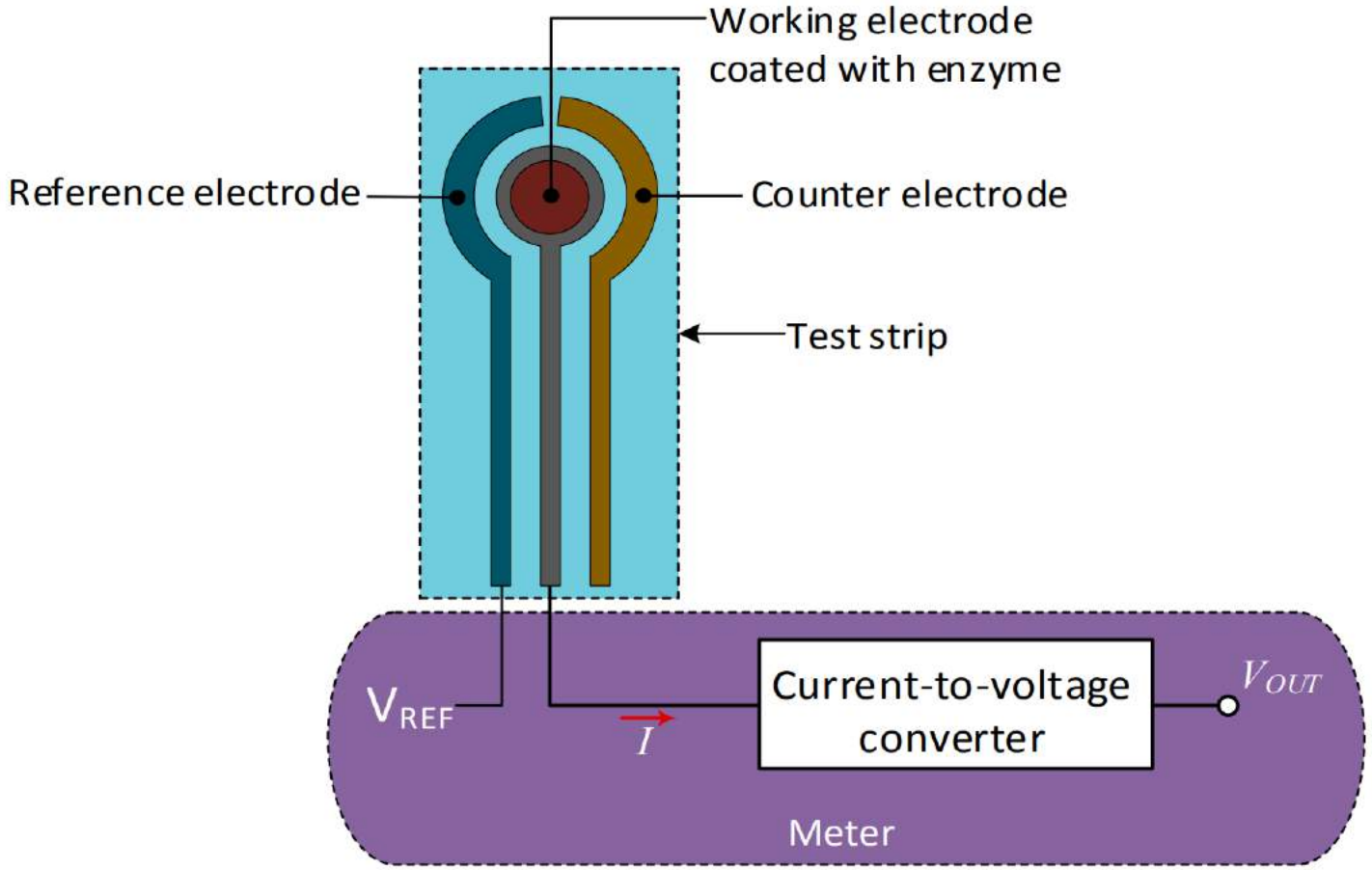
İnvitro Yöntemler
Enzimatik-amperometrik metod



İnvitro;
Hekzokinaz yöntemi



SMBG
Kendi kendine glukoz ölçümleri

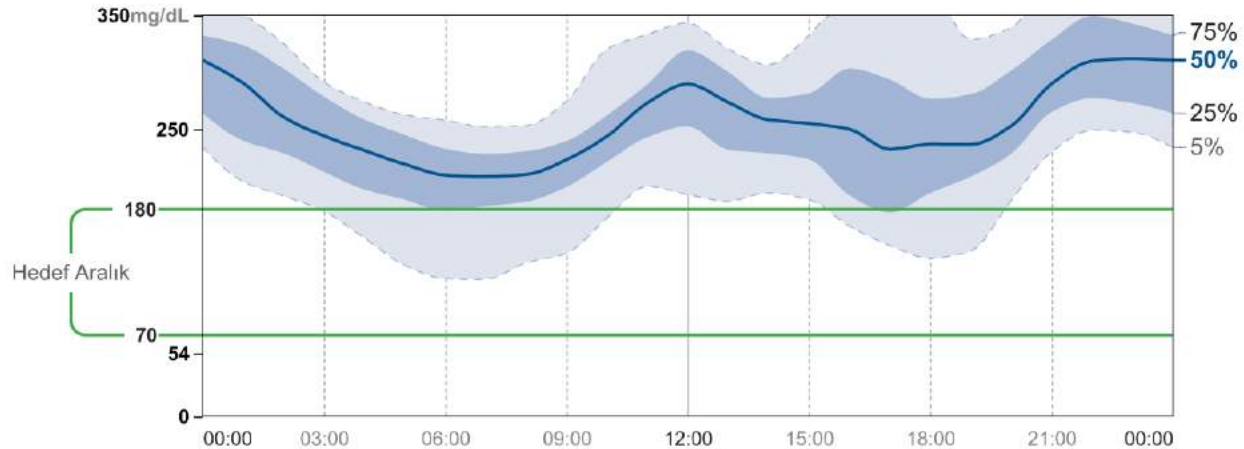


CGMS
Kana göre 6-12 dakika gecikmeli ölçme

- Kablosuz alıcı
- RF
- Transmitter
- Sensor; Glukoz oksidaz -platin .....Üretilen voltaj
  - (Dokular arası sıvıya yerleştirilmiş)

AMBULATUVAR GLUKOZ PROFİLİ (AGP)

AGP, tek bir günde gerçekleşiyormuş gibi gösterilen medyan (%50) ve diğer persantiller ile rapor dönemindeki glikoz değerlerinin bir özetidir.

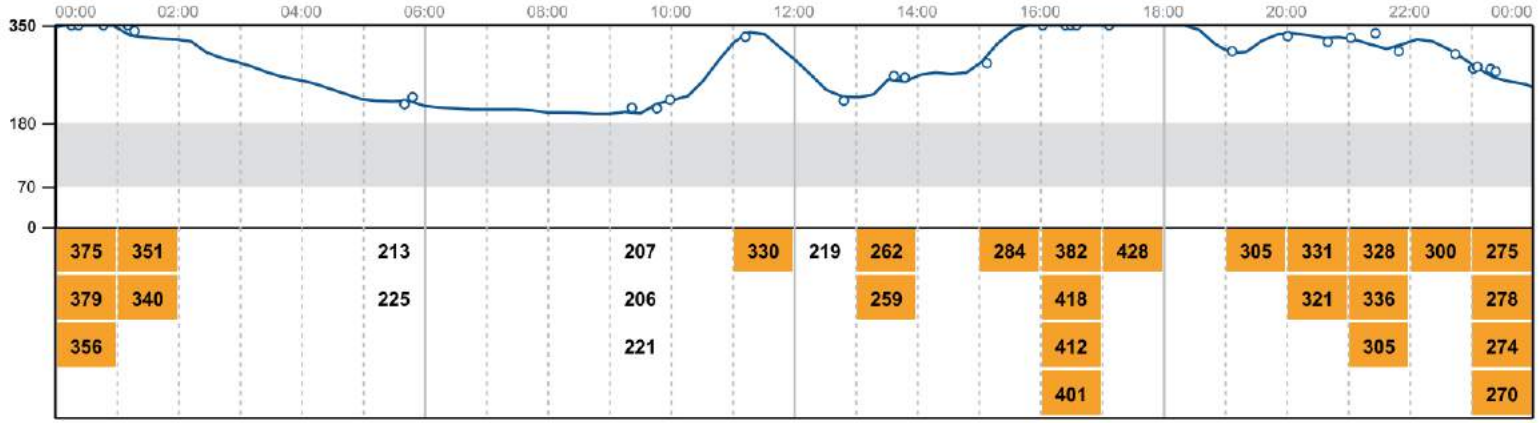


GÜNLÜK GLUKOZ PROFİLİ

Her günlük profil, sol üst köşede görüntülenen tarihin gece yarısından gece yarısına kadarki aradaki süreyi temsil eder.

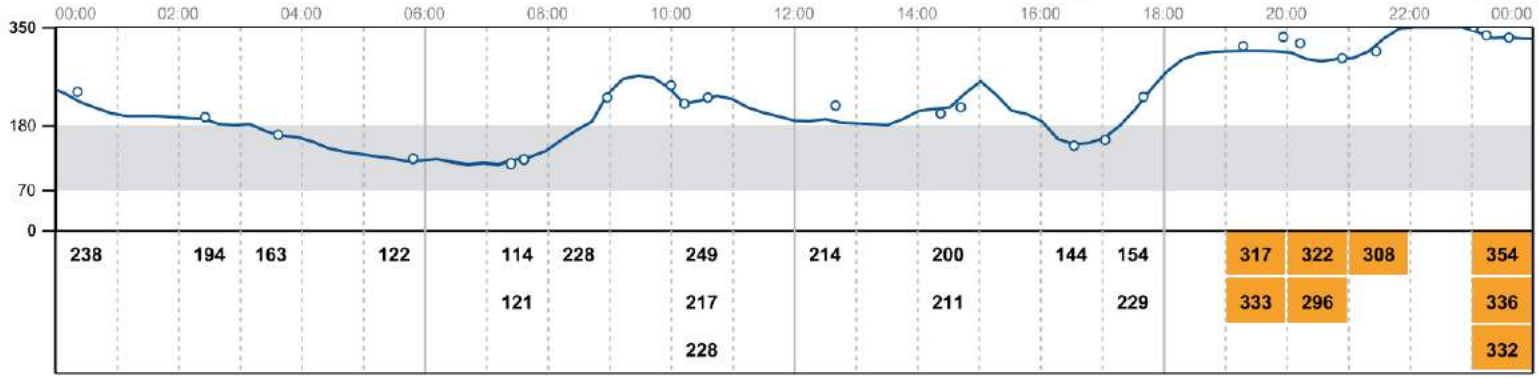
SAL **23 Şub**

Glukoz mg/dL



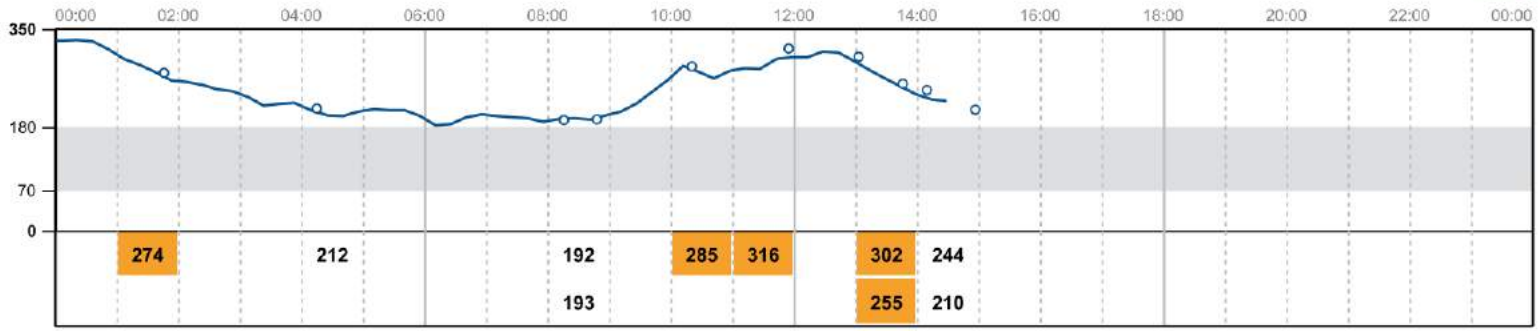
ÇAR **24 Şub**

Glukoz mg/dL



PER **25 Şub**

Glukoz mg/dL



Bazı ülkelerde onaylı glukoz ölçüm yöntemleri

Agency	Country	Guideline/Sta	Release Year	Device Type	Glucose Concentration	Criteria
Food & Drug Administration (FDA)	USA [47,48]	UCM 380325	2016	BGMS	≥75 mg/dL	95% within ±12% 98% within ±15%
					<75 md/dL	95% within ±12 mg/dL 98% within ±15 mg/dL
		UCM 380327		SMBG	Entire range	95% within ±15% 99% within ±20%
European Medicines Agency (EMA)	EU [49]	EN ISO 15197	2015	BGMS/SMBG	≥100 mg/dL	95% within ±15%
Health Canada	Canada [50]	ISO 15197	2013		<100 mg/dL	95% within ±15 mg/dL
Agência Nacional de Vigilância Sanitária (ANVISA)	Brazil [51]					
China Food & Drug Administration (CFDA)	China [52]					
Pharmaceuticals and Medical Devices Agency (PMDA)	Japan [53,54]					
Therapeutic Goods Administration TGA	Australia [55–57]				Entire range (Type 1 Diabetes)	99% within Zones A & B of Parkes Error Grid

Türkiyede onay kurumu

TİCK Güvensiz ürün listesi

ZİNDE-LAB SAĞLIK HİZ. LTD. ŞTİ	ACON marka On Call Plus Kan Şekeri Cihazı	3365849	O682607535118	ABD	Analiz Sonucu Uygunsuz	07.08.2017
Al-Fe Tıp Sağlık Hizmetleri Ltd. Şti.	Rheamed marka Rheamed marka Kan Şekeri İzleme Sistemi	NK2401	4712805620265	Tayvan	Analiz Sonucu Uygunsuz	07.12.2017
Nanotek Medikal Limited Şirketi	Caresens marka Caresens II Kan Şekeri Ölçüm Cihazı (GM505C model)	C0A036E000001-C0A036E000950	8809126640143	Güney kore	Analiz Sonucu Uygunsuz	07.12.2017
Olgun Medikal İnş. Ve Tic. Ltd. Şti.	Glucosfia marka Glucosfia Linda Kan Şekeri Ölçüm Cihazı	P/N: 7K-CS003P00N	4260236850275	Almanya	Analiz Sonucu Uygunsuz	07.12.2017

TİCK Güvensiz ürün listesi

İme Dc Sağlık Ürünleri San. ve Tic. Ltd. Şti.	Ime-Dc Marka Fidelity Kan Şeker Ölçüm Cihaz Seti	SN-H16J00001-00040/SN-H15J00301-000480/SN-H15J00601-00920	4260155930089	ALMANYA	Analiz Sonucu Uygunsuz	08.08.2017

TC Şeker Ölçüm Cihaz Şartnameleri

KODU: 398547

KAN ŞEKERİ ÖLÇÜMÜ (STRİP VEYA MİKRO KÜVET) TEKNİK ŞARTNAMESİ

398547 kodlu malzeme için aşağıdaki şartlar geçerlidir:

1. Bu kaleme teklif verecek firma stripler ile birlikte 150 adet cihaz verilmelidir. Verilecek cihazların özellikleri aşağıda belirtilen özelliklere sahip olmalıdır:
   - **i.** Sistem biyosensör veya elektrokimyasal yöntemle ölçüm yapmalıdır.
   - **ii.** Yapılacak ölçümler uluslararası doğruluk standardı (ISO:2013:15197) gerekliliklerini karşılamalıdır.
   - **iii.** Kan şekeri ölçüm aralığı en az 20-500 mg/dl olmalıdır.
   - **iv.** Ölçüm süresi en fazla 5 saniye olmalıdır.
   - **v.** Hastane protokolüne göre belirlenen yüksek ve düşük seviyeler dışındaki sonuçlar için cihaz uyarı vermelidir.

Glycemic targets

Table 6.3—Summary of glycemic recommendations for many nonpregnant adults with diabetes

A1C	<7.0% (53 mmol/mol)*#
Preprandial capillary plasma glucose	80–130 mg/dL* (4.4–7.2 mmol/L)
Peak postprandial capillary plasma glucose†	<180 mg/dL* (10.0 mmol/L)

*More or less stringent glycemic goals may be appropriate for individual patients. #CGM may be used to assess glycemic target as noted in Recommendation 6.5b and **Fig. 6.1**. Goals should be individualized based on duration of diabetes, age/life expectancy, comorbid conditions, known CVD or advanced microvascular complications, hypoglycemia unawareness, and individual patient considerations (as per **Fig. 6.2**). †Postprandial glucose may be targeted if A1C goals are not met despite reaching preprandial glucose goals. Postprandial glucose measurements should be made 1–2 h after the beginning of the meal, generally peak levels in patients with diabetes.

Glycemic Targets:
Standards of Medical Care in Diabetes - 2021. *Diabetes Care* 2021;44(Suppl. 1):S73-S84

Table 7.1—Comparison of ISO 15197:2013 and FDA blood glucose meter accuracy standards

Setting	FDA (206,207)	ISO 15197:2013 (208)
Home use	95% within 15% for all BG in the usable BG range† 99% within 20% for all BG in the usable BG range†	95% within 15% for BG ≥100 mg/dL 95% within 15 mg/dL for BG <100 mg/dL 99% in A or B region of consensus error grid‡
Hospital use	95% within 12% for BG ≥75 mg/dL 95% within 12 mg/dL for BG <75 mg/dL 98% within 15% for BG ≥75 mg/dL 98% within 15 mg/dL for BG <75 mg/dL	

BG, blood glucose; FDA, U.S. Food and Drug Administration; ISO, International Organization for Standardization. To convert mg/dL to mmol/L, see http://endmemo.com/medical/unitconvert/Glucose.php. †The range of blood glucose values for which the meter has been proven accurate and will provide readings (other than low, high, or error). ‡Values outside of the "clinically acceptable" A and B regions are considered "outlier" readings and may be dangerous to use for therapeutic decisions (209).

Diabetes Technology:
Standards of Medical Care in Diabetes - 2021. *Diabetes Care* 2021;44(Suppl. 1):S85-S99

Table 7.2—Interfering substances for glucose readings

Glucose oxidase monitors
Uric acid
Galactose
Xylose
Acetaminophen
L-DOPA
Ascorbic acid
Glucose dehydrogenase monitors
Icodextrin (used in peritoneal dialysis)

Diabetes Technology:
Standards of Medical Care in Diabetes - 2021. *Diabetes Care* 2021;44(Suppl. 1):S85-S99

Table 7.3—Continuous glucose monitoring (CGM) devices

Type of CGM	Description
Real-time CGM (rtCGM)	CGM systems that measure and display glucose levels continuously
Intermittently scanned CGM (isCGM)	CGM systems that measure glucose levels continuously but only display glucose values when swiped by a reader or a smartphone
Professional CGM	CGM devices that are placed on the patient in the provider's office (or with remote instruction) and worn for a discrete period of time (generally 7–14 days). Data may be blinded or visible to the person wearing the device. The data are used to assess glycemic patterns and trends. These devices are not fully owned by the patient—they are a clinic-based device, as opposed to the patient-owned rtCGM/isCGM devices.

Diabetes Technology:
Standards of Medical Care in Diabetes - 2021. *Diabetes Care* 2021;44(Suppl. 1):S85-S99

İn vivo Glukoz Ölçüm Yöntemleri

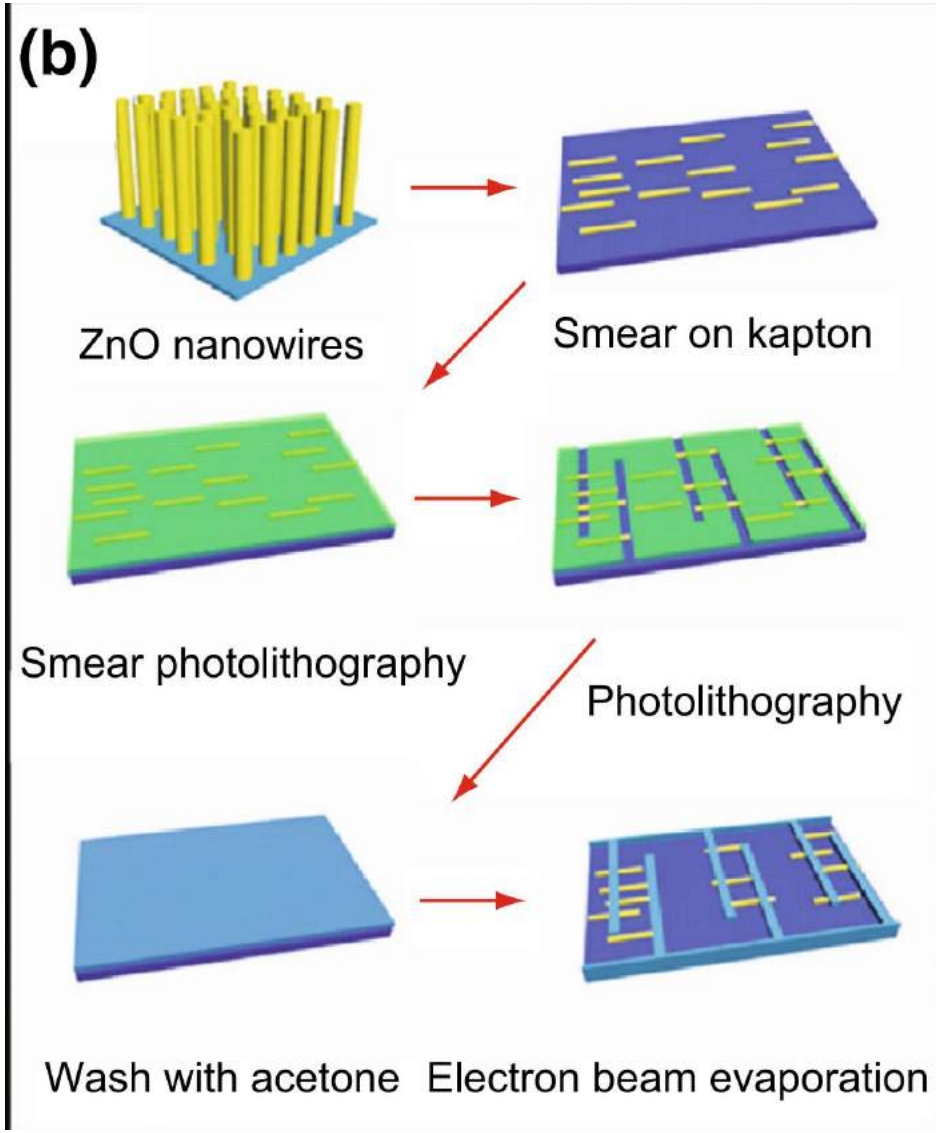
- Cilt üzerinden
- Nefes
- Tükrük
- Dokular arası sıvıdan
- Kandan

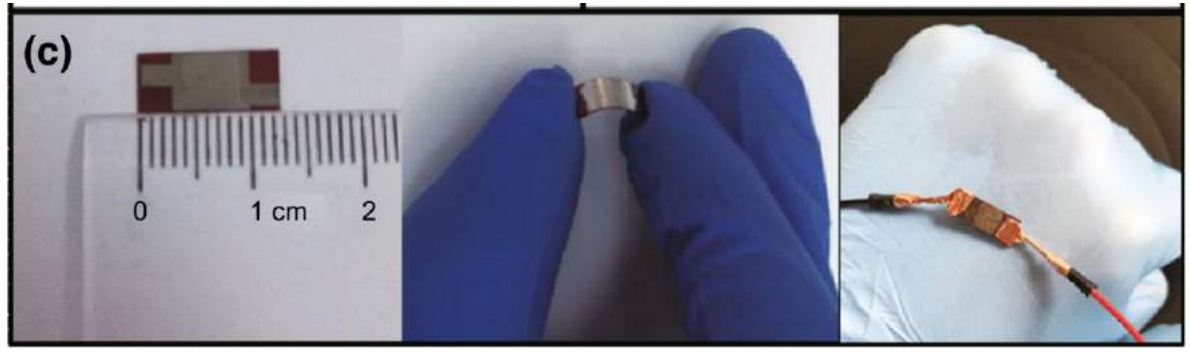
Self-Powered Implantable Skin-Like Glucometer for Real-Time Detection of Blood Glucose Level In Vivo

Wanglinhan Zhang,[#1] Linlin Zhang,[#1] Huiling Gao,[2] Wenyan Yang,[1] Shuai Wang,[1] Lili Xing,[1] and Xinyu Xue[1]

Nanomicro Lett. 2018; 10(2): 32.
Published online 2018 Jan 4. doi: 10.1007/s40820-017-0185-x

Cihazın yapısı

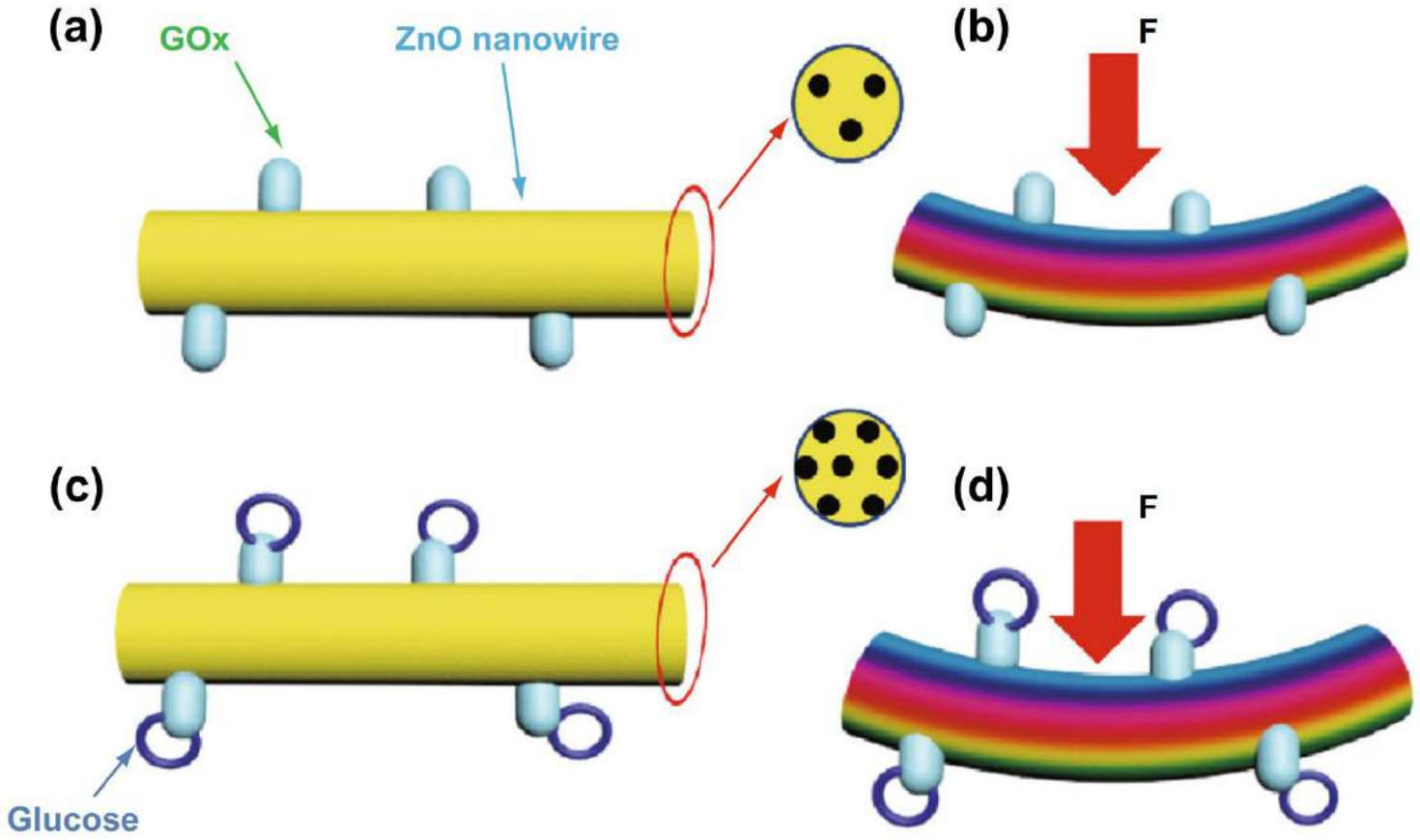




Potential application, device architecture, material system, and experimental design of self-powered implantable skin-like glucometer. a Potential application. b Device architecture, material system, and fabrication procedure. c Optical images of the device

Teknik yapı

GOx; Glukoz oksidaz

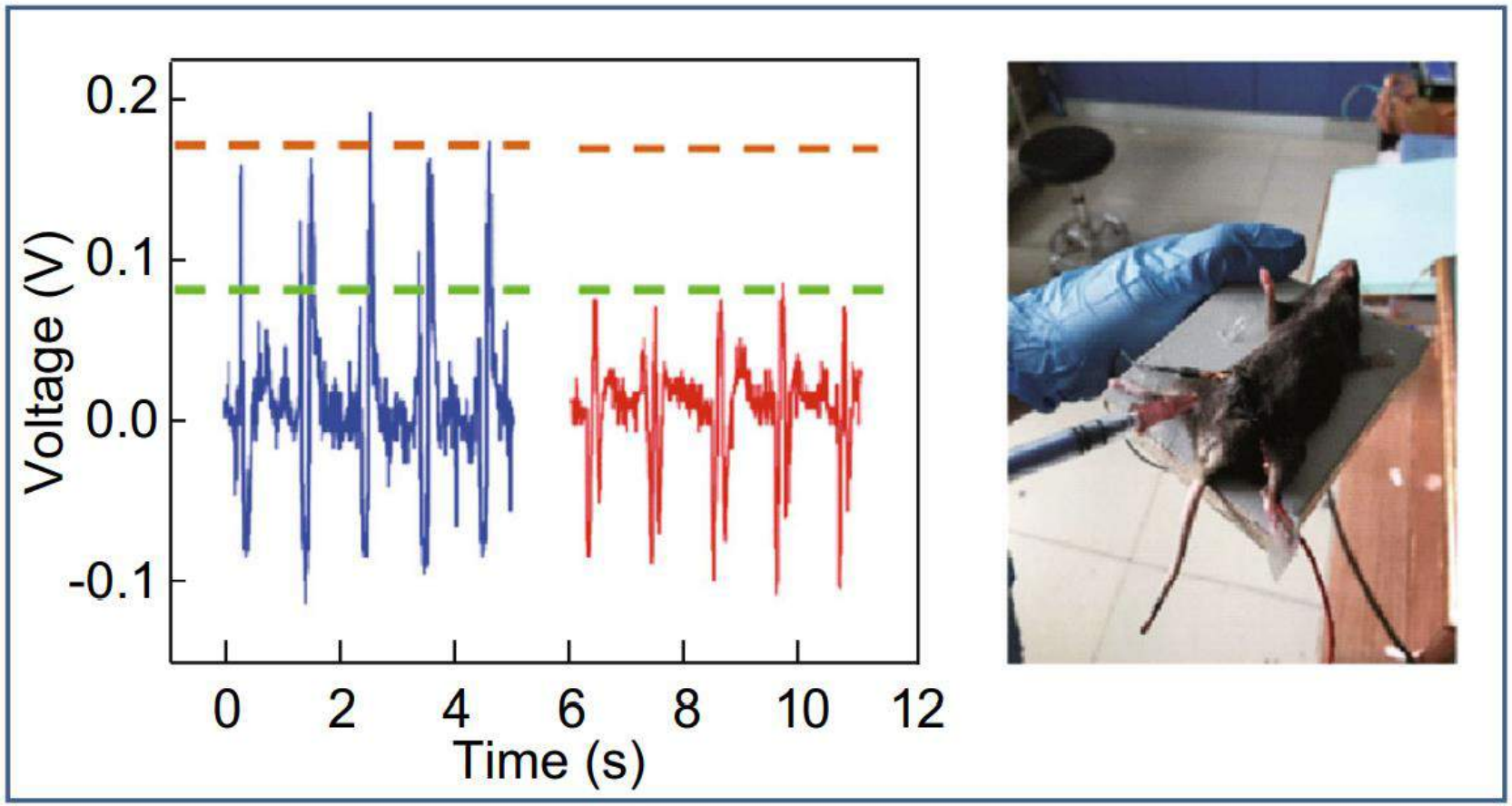


$$\text{Glucose} + H_2O + O_2 \xrightarrow{GOx} \text{Gluconic acid} + H_2O_2$$

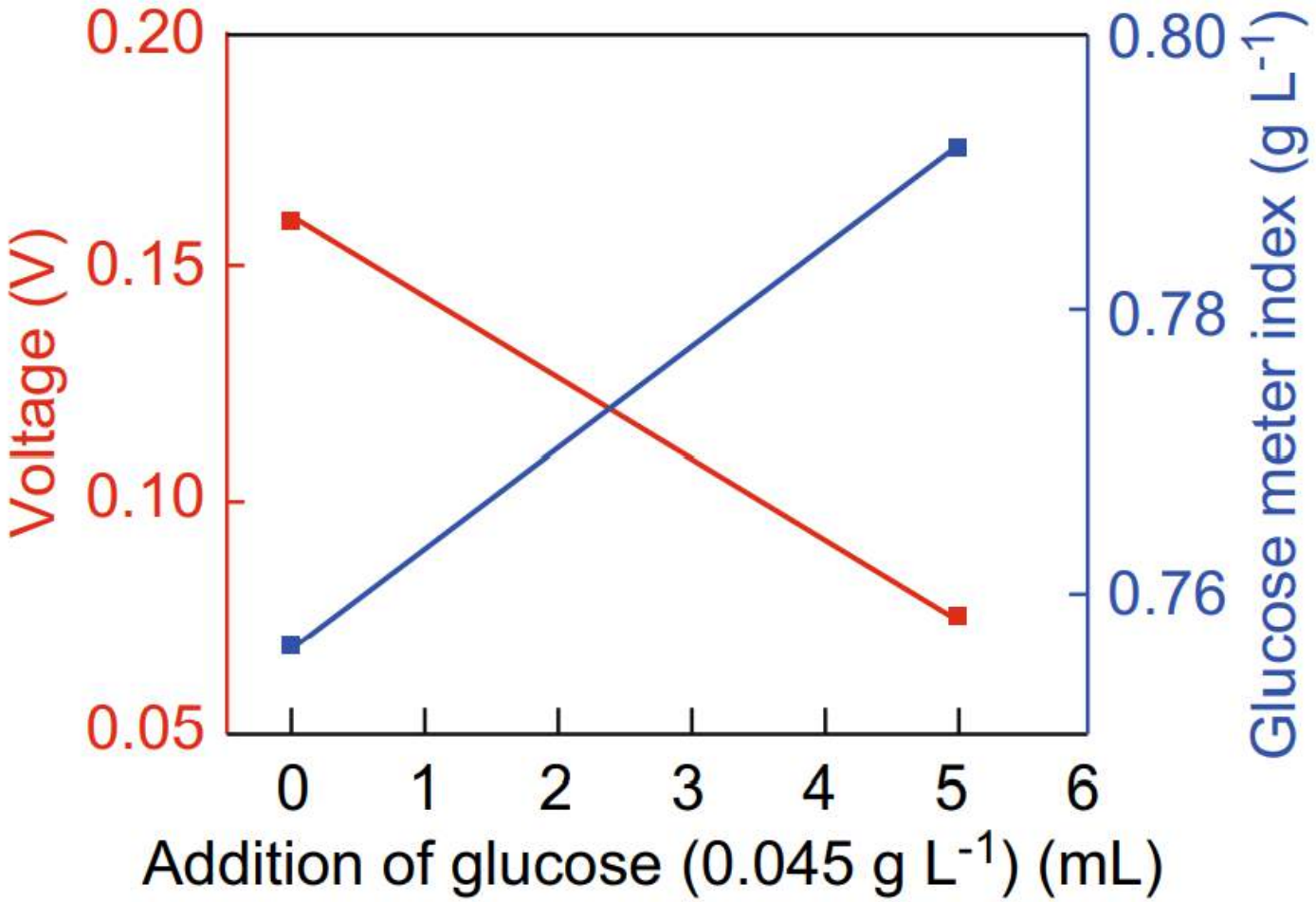
$$H_2O_2 \rightarrow 2H^+ + O_2 + 2e^-$$

Elektrodun intraabdominal yerleştirilmesi

Elektrot büyüklüğü
260 mikrometre


0.2
0.1
0.0
-0.1
Voltage (V)
0
2
4
6
8
10
12
Time (s)

Glukoz ve voltaj ilişkisi



Transl Res. Author manuscript; available in PMC 2020 Nov 1.
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Published online 2019 May 30. doi: 10.1016/j.trsl.2019.05.006

PMCID: PMC6783357
NIHMSID: NIHMS1533115
PMID: 31194942

Non-Invasive Glucose Detection in Exhaled Breath Condensate

Divya Tankasala[1] and Jacqueline C. Linnes, PhD[1,*]

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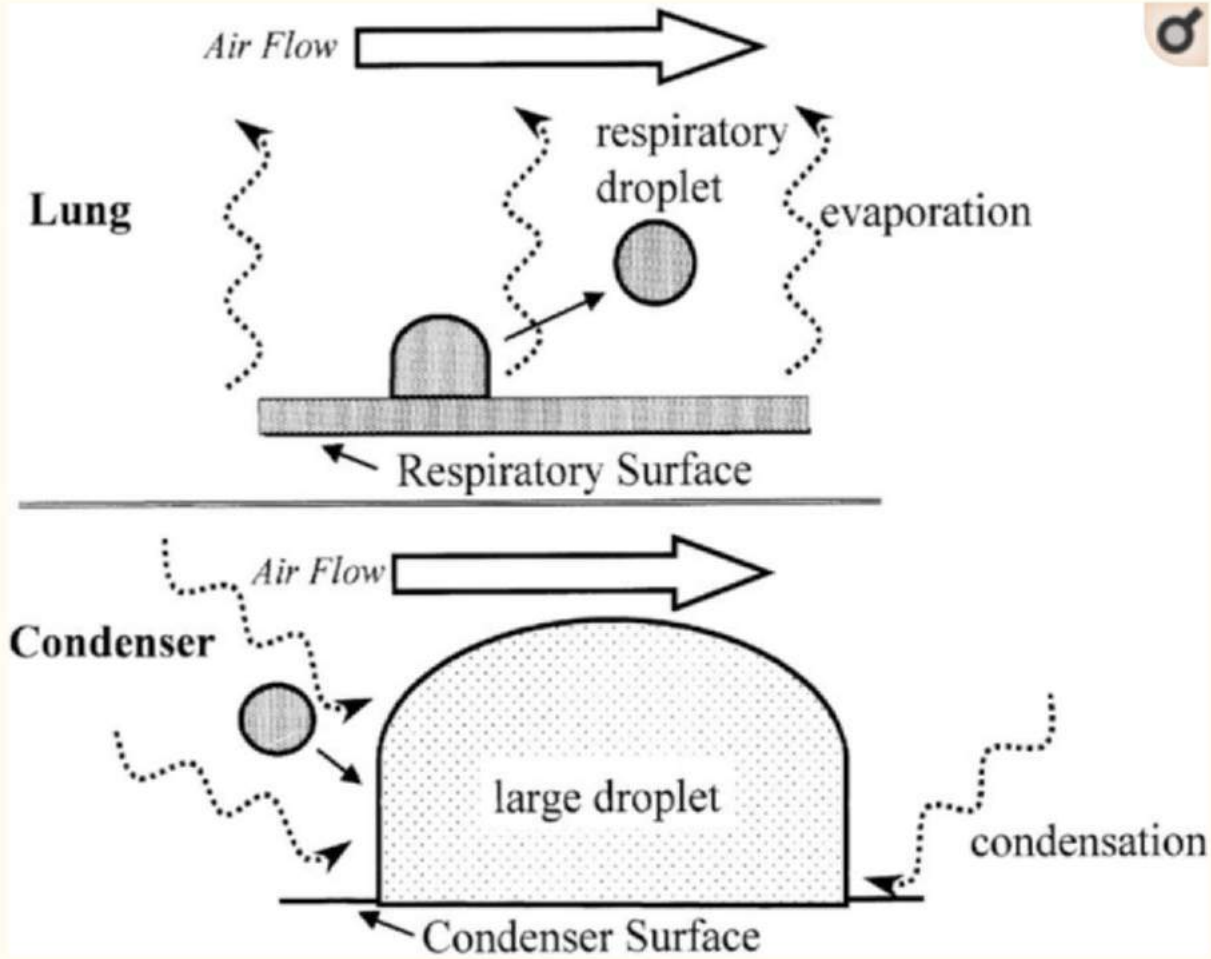
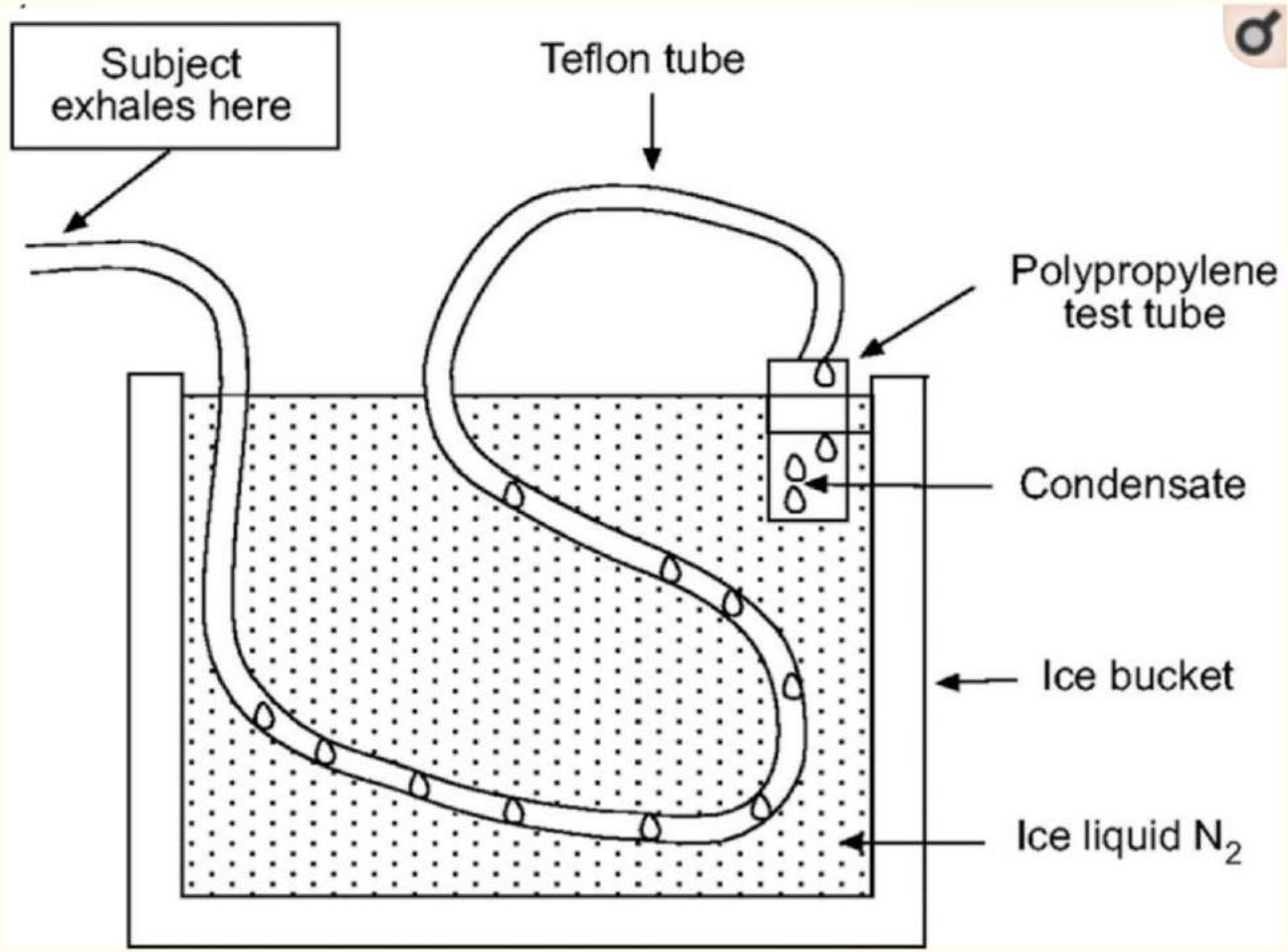

Air Flow
Lung
respiratory
droplet
evaporation
Respiratory Surface
Air Flow
Condenser
large droplet
condensation
Condenser Surface


Subject exhales here
Teflon tube
Polypropylene test tube
Condensate
Ice bucket
Ice liquid N_2

Comparative Study > J Diabetes Sci Technol. 2015 Jan;9(1):91-6.

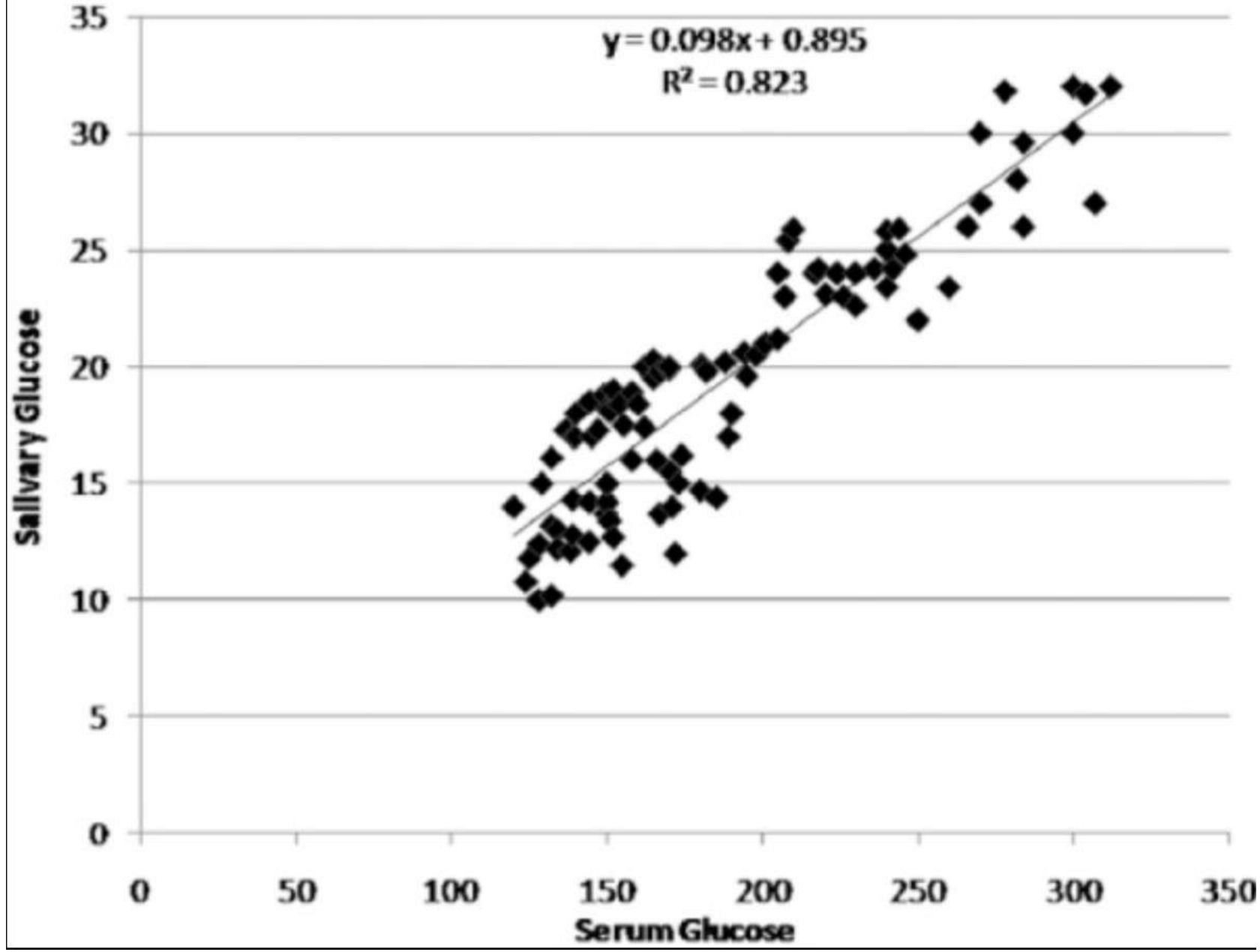
doi: 10.1177/1932296814552673. Epub 2014 Oct 7.

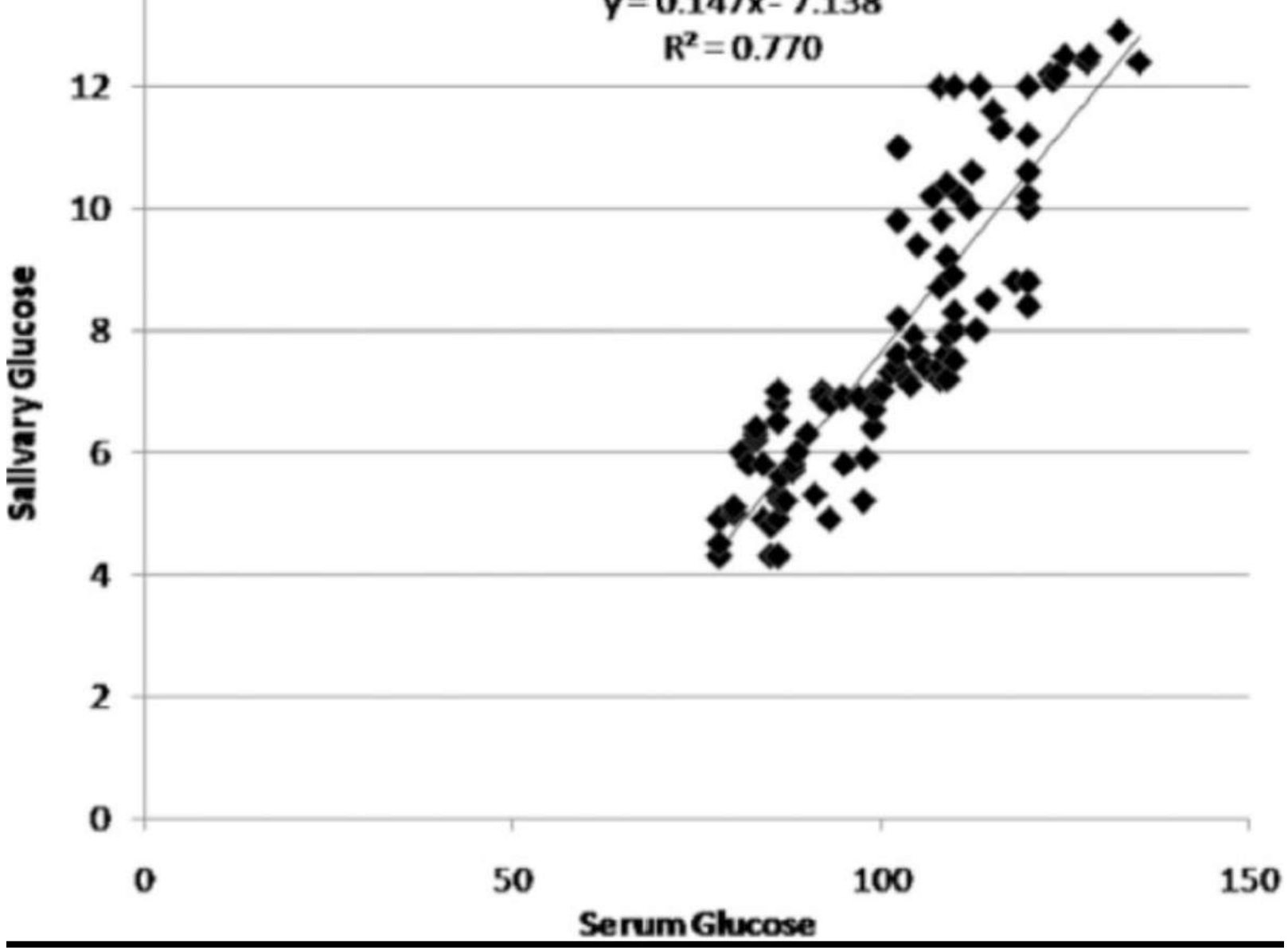
Comparison of salivary and serum glucose levels in diabetic patients

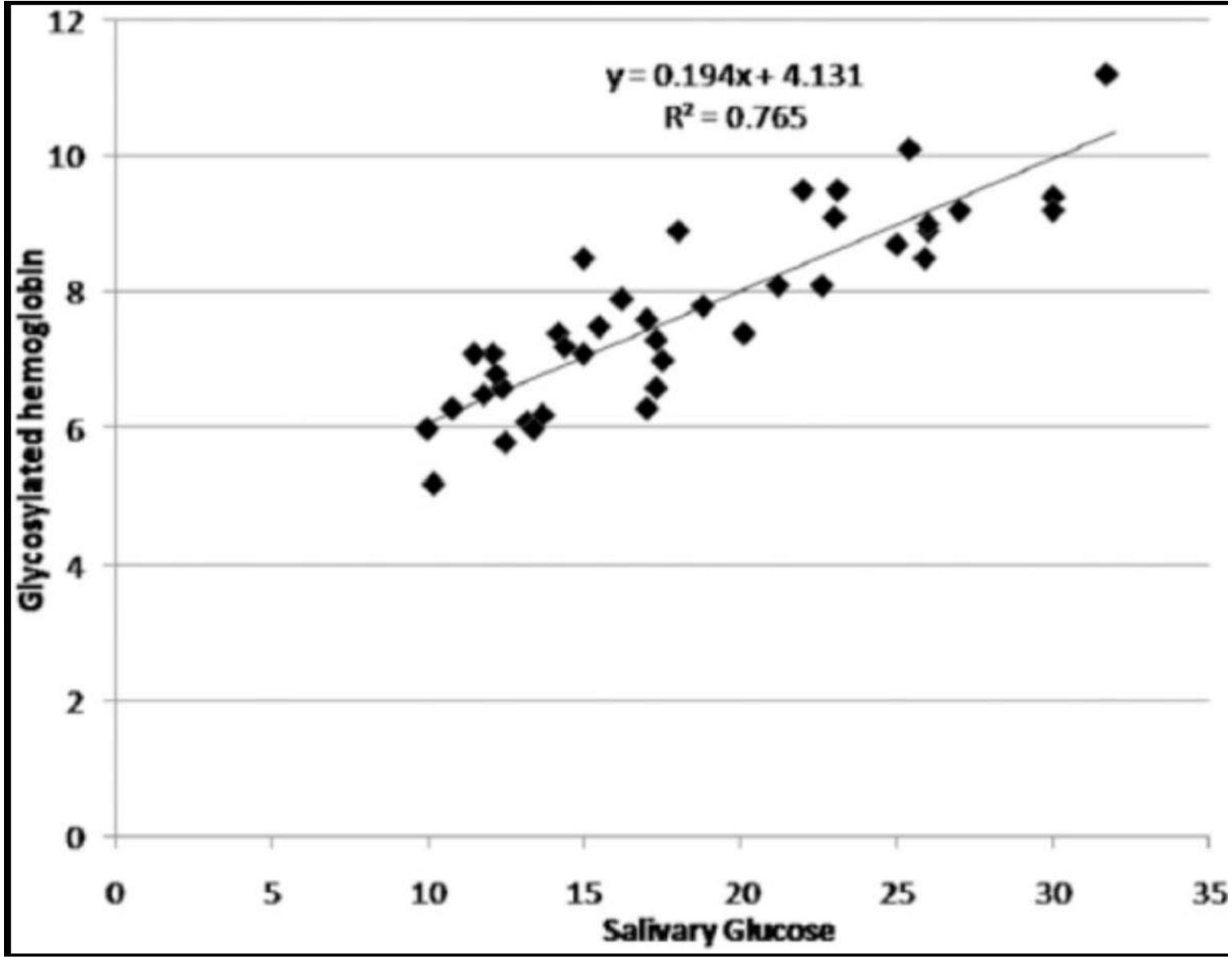
Shruti Gupta [1], Simarpreet Virk Sandhu [2], Himanta Bansal [3], Deepti Sharma [4]

Affiliations + expand

PMID: 25294888 PMCID: PMC4495535 DOI: 10.1177/1932296814552673


y = 0.098x + 0.895
R² = 0.823
Sallvary Glucose
Serum Glucose
0
5
10
15
20
25
30
35
0
50
100
150
200
250
300
350


y = 0.147x - 7.138
R² = 0.770
12
10
8
6
4
2
0
Sallvary Glucose
0
50
100
150
Serum Glucose


y = 0.194x + 4.131
R² = 0.765
Glycosylated hemoglobin
Salivary Glucose
0
2
4
6
8
10
12
0
5
10
15
20
25
30
35

› Niger J Clin Pract. Jul-Aug 2016;19(4):486-90. doi: 10.4103/1119-3077.183314.

Salivary glucose as a diagnostic tool in Type II diabetes mellitus: A case–control study

M Dhanya [1], S Hegde [1]

Affiliations + expand

PMID: 27251965 DOI: 10.4103/1119-3077.183314

Variables	Salivary glucose level in controls	Salivary glucose level in diabetics
Blood glucose level in controls	$R=0.6342^{*}$	
Blood glucose level in diabetics		$R=0.8809^{*}$

$^{*}=P<0.01$

biosensors

MDPI

Review

A Review of the Construction of Nano-Hybrids for Electrochemical Biosensing of Glucose

Razia Batool [1], Amina Rhouati [2], Mian Hasnain Nawaz [1], Akhtar Hayat [1,*] and Jean Louis Marty [3,*]

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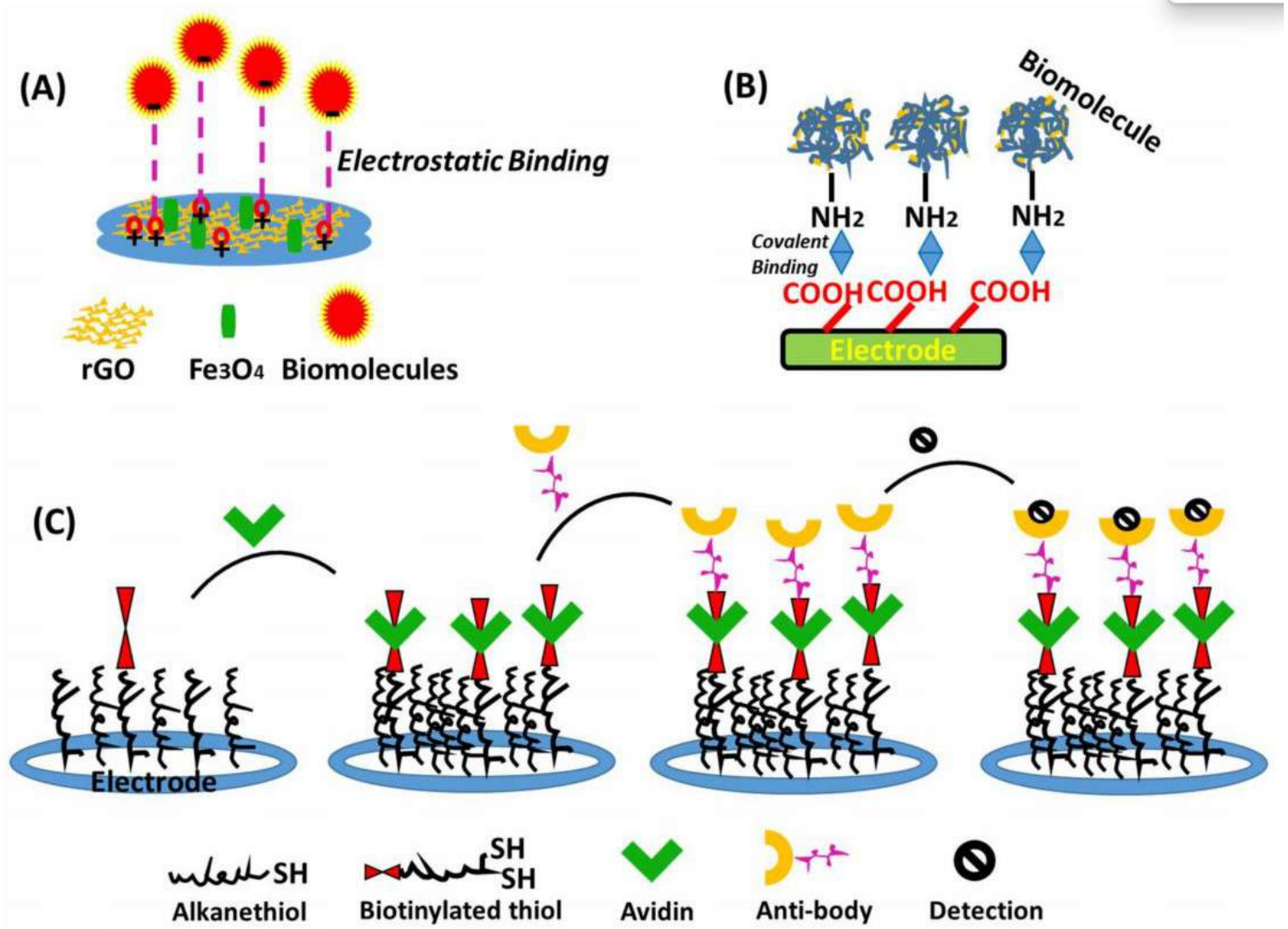
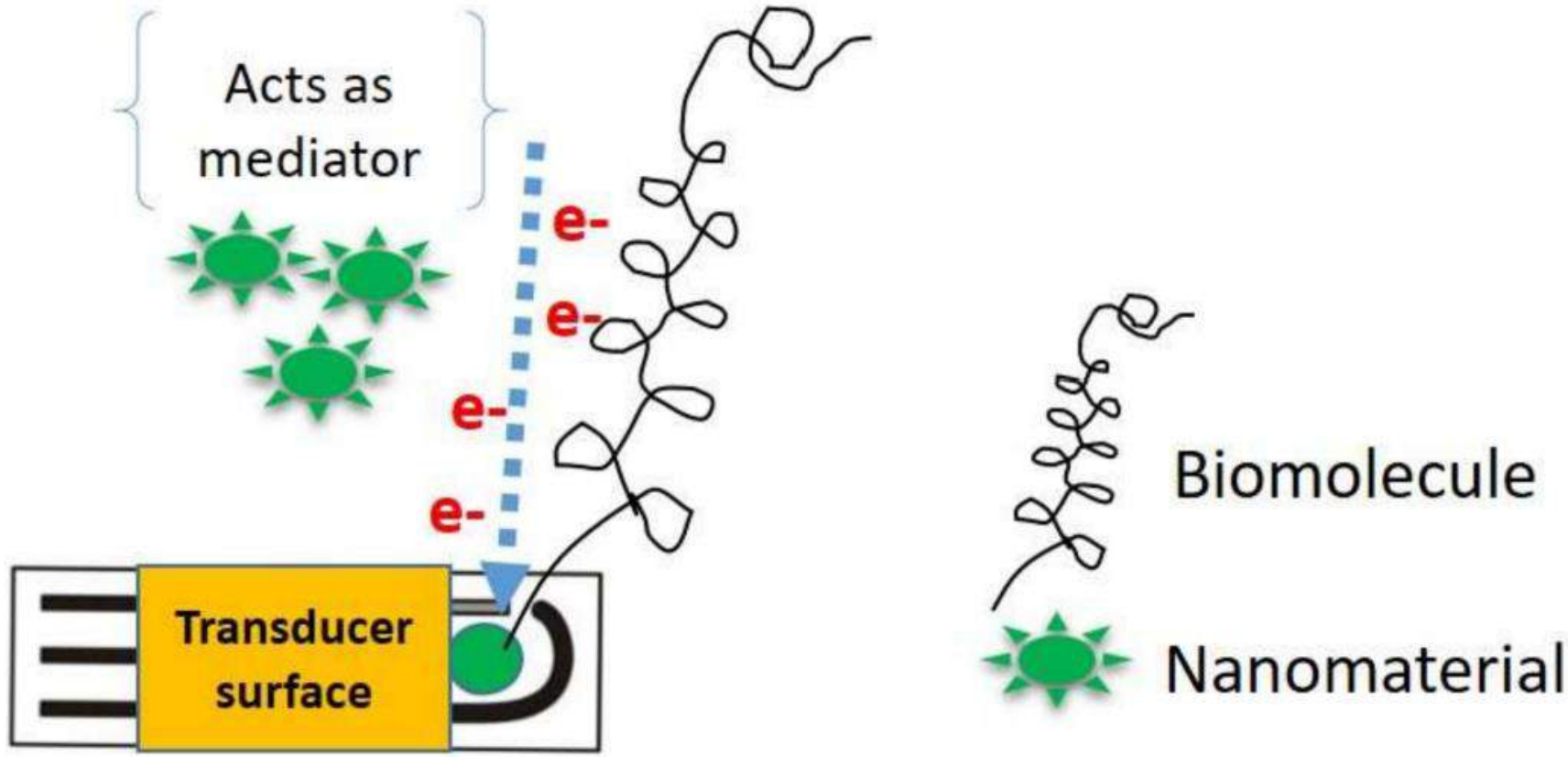
* Correspondence: akhtarhayat@ciitlahore.edu.pk (A.H.); jlmarty@univ-perp.fr (J.L.M.)

Received: 27 February 2019; Accepted: 22 March 2019; Published: 25 March 2019

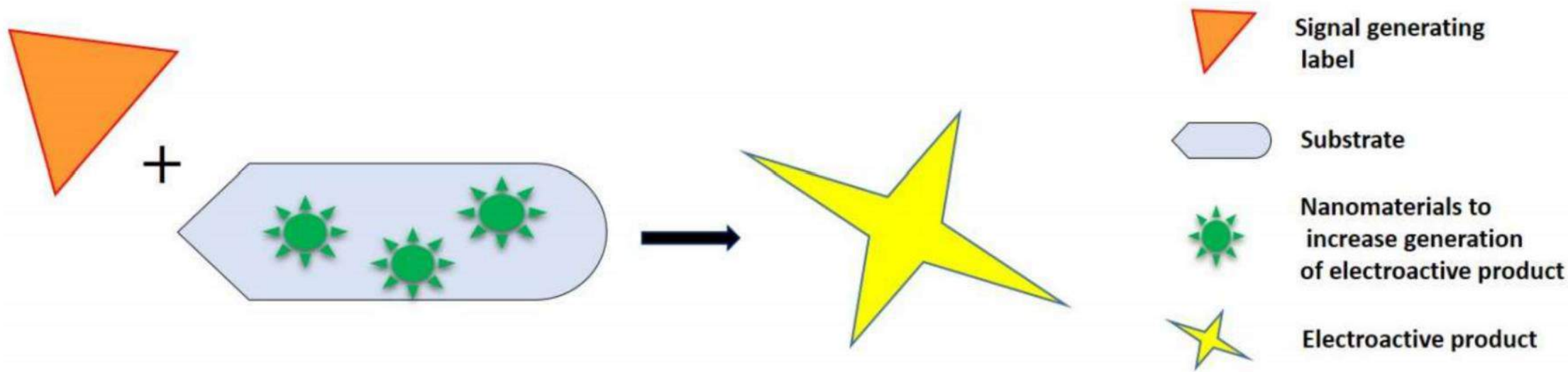
Overview of nanomaterial-based transducer surfaces in electrochemical biosensors; (A) Electrostatic binding; (B) covalent binding and (C) affinity binding



Nanomaterials as mediators in electrochemical biosensors



Integration of nanomaterials towards signal amplification of electrochemical biosensors.



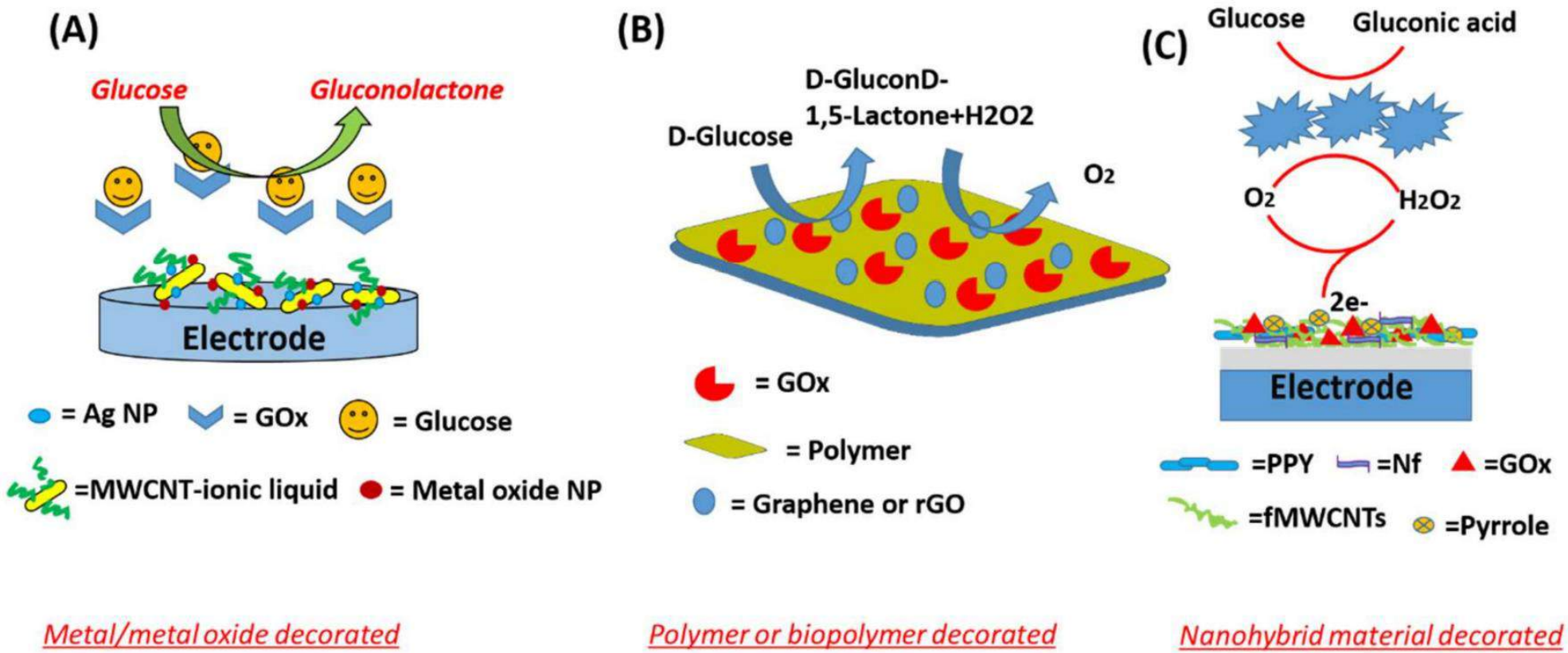


Figure 4. Illustration of types of carbon-based nano-hybrid and nano-composite materials in electrochemical glucose biosensors (**A**) AgNP/MWCNT; (**B**) rGO/Polymer and (**C**) fMWCNT/Polypyrrole.

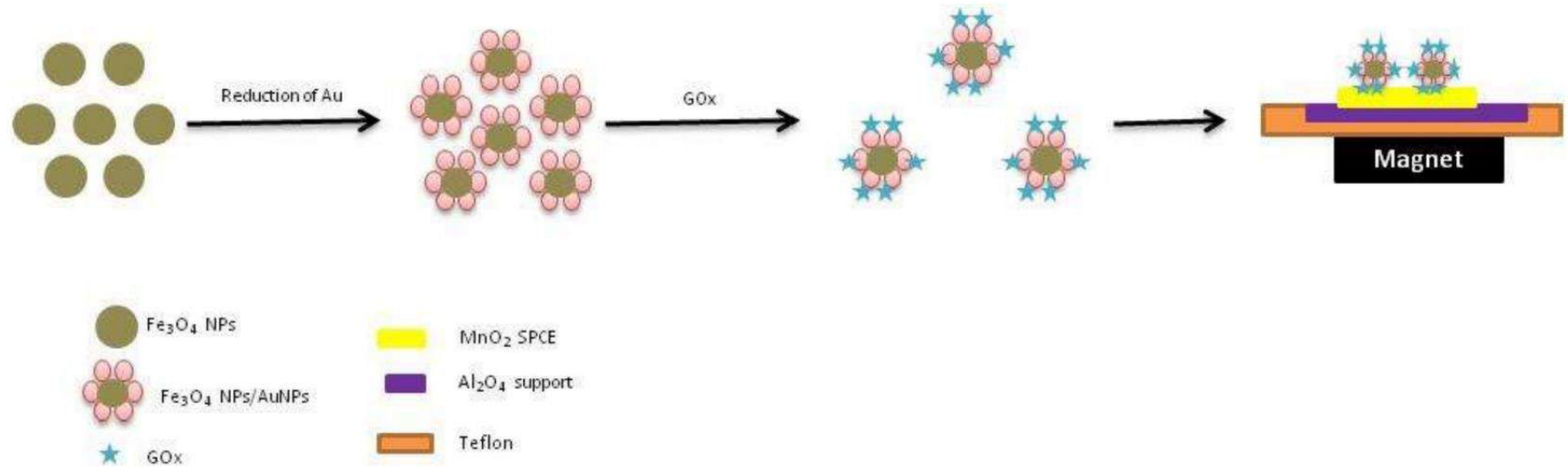


Figure 5. Schematic representation of flow-injection-based amperometric glucose biosensor. Glucose oxidase was immobilized on Fe_3O_4 core nanoparticles in association with Au seeds [78].

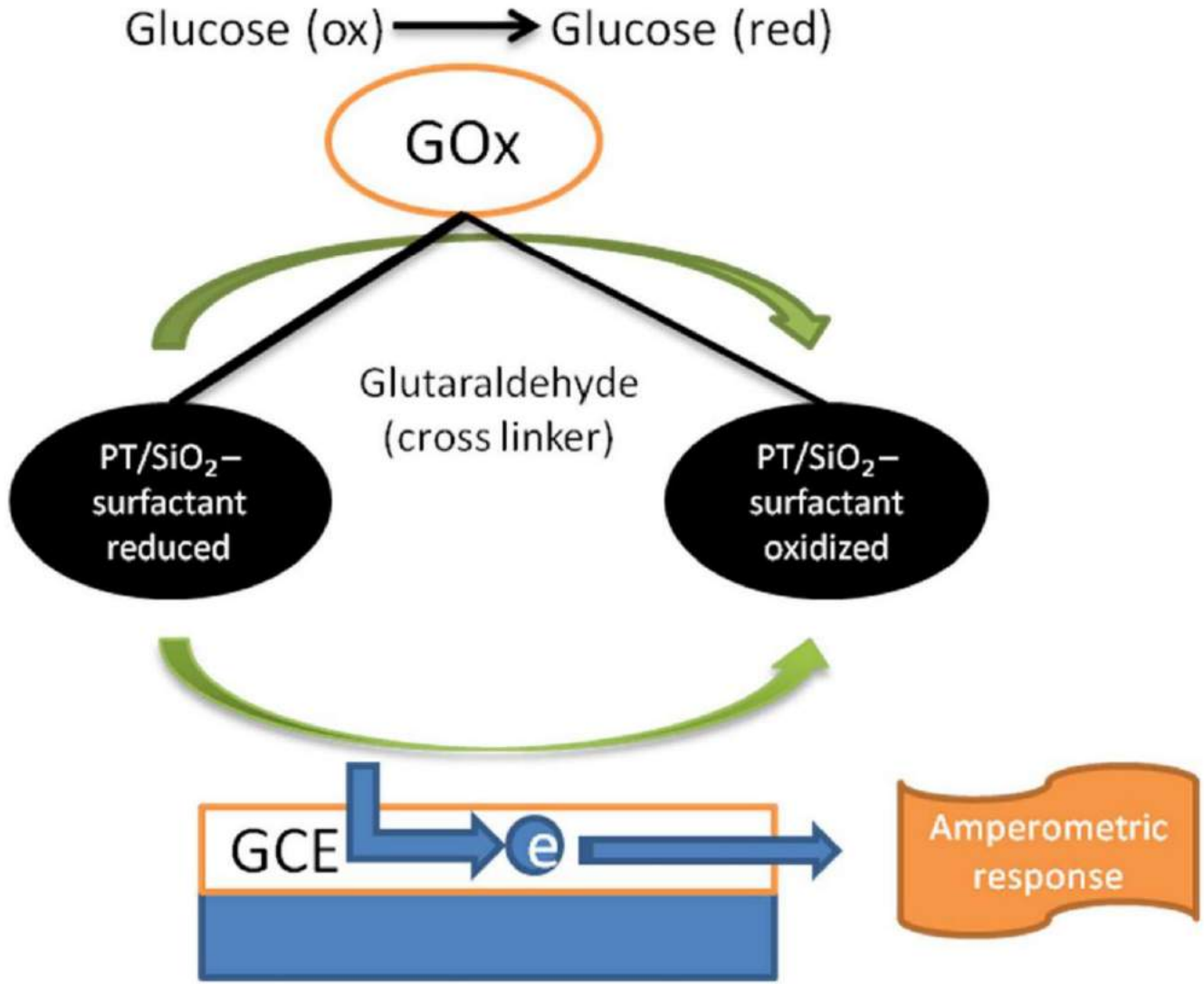


Figure 6. Representation of an amperometric glucose biosensor based on a polythiophene/SiO_2 nano-composite in the presence of surfactants [101].