CGM
&
Insulin
Pumps

USES & MISUSES OF

Continuous Glucose Sensors & Insulin Pumps: Good Pumps Gone Bad

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Disclosures & CME Statement

- No disclosures
- No relevant financial relationships to disclose

Learning Objectives

1. Explain the technical principles behind CGM and CSII (continuous subcutaneous insulin infusion)
2. Identify appropriate patient selection criteria for CGM and insulin pump therapy
3. Recognize common clinical misuses, errors, and pitfalls associated with these technologies
4. Troubleshoot real-world clinical scenarios involving CGM and pump malfunctions

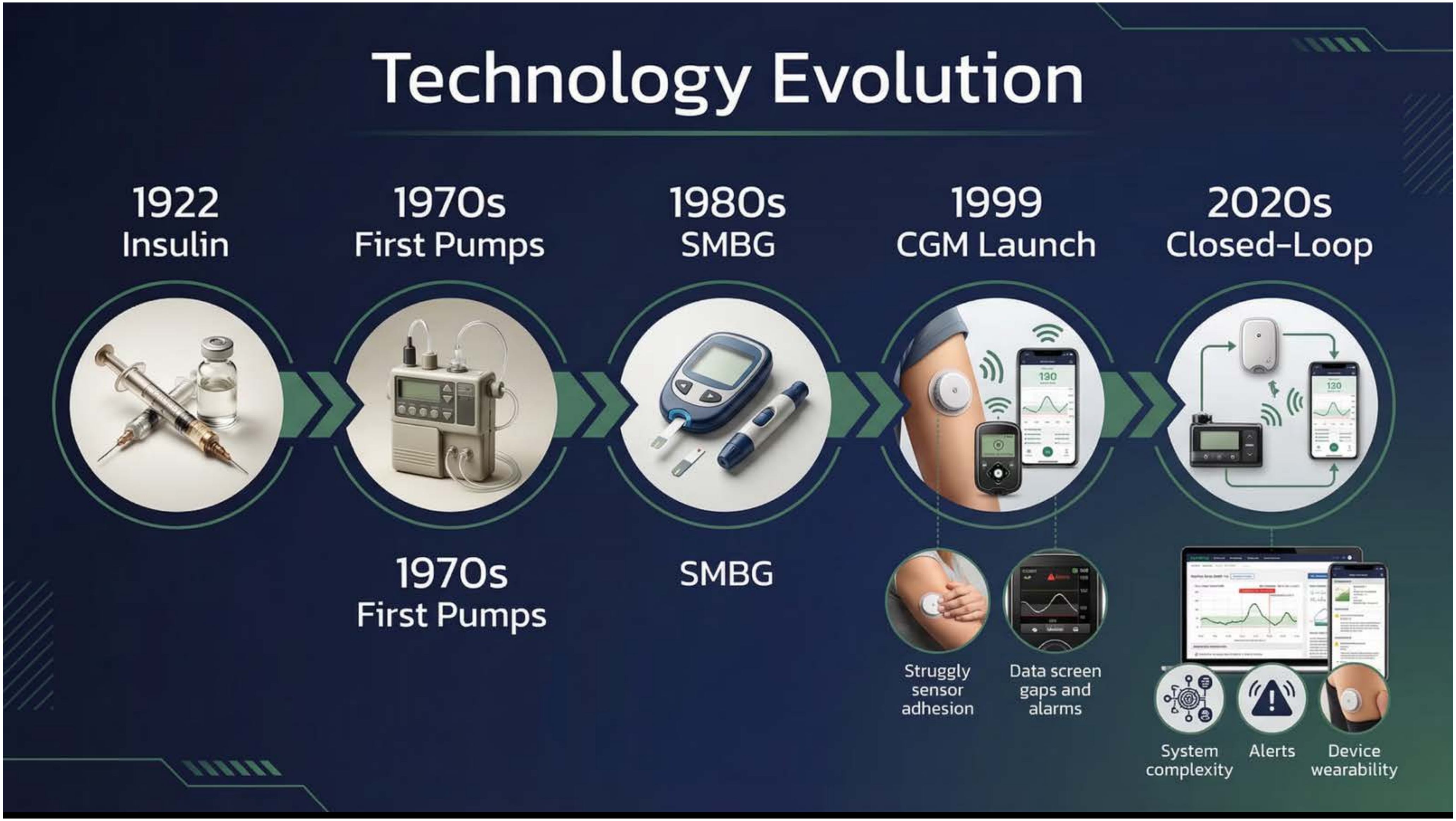
The Diabetes Burden: Why Technology Matters

800 M	~40 M	10%
Adults with diabetes worldwide	DM patients in the United States	HbA1c reduction with closed-loop systems

The DCCT (1993)-intensive glucose control reduces microvascular complications by 60–76%.
Achieving near-normal glycemia safely requires tools beyond traditional fingerstick and MDI therapy.

- **1921** Insulin discovery
- **1963** First insulin pump
- **1999** First CGM (GlucoWatch)
- **2016** Hybrid closed loop
- **2024** Fully closed loop systems

IDF Diabetes Atlas 2023. ADA Standards of Care 2024. NEJM 1993;329:977-986 (DCCT).



Technology Evolution
1922
Insulin
1970s
First Pumps
1980s
SMBG
1999
CGM Launch
2020s
Closed-Loop
1970s
First Pumps
SMBG
Struggly sensor adhesion
Data screen gaps and alarms
System complexity
Alerts
Device wearability

History of Insulin Pumps

From backpack-sized devices to closed-loop systems

1963	**Dr. Arnold Kadish:**	First wearable insulin pump — worn as a backpack, delivered insulin.
1978	**Dean Kamen's 'Auto-Syringe':**	First commercially available CSII pump. Large, external, worn on belt.
1983	**MiniMed 502:**	Miniaturized pump. Subcutaneous infusion becomes feasible. Used by early adopters with T1DM.
1990s	**Rapid proliferation:**	Multiple manufacturers enter market. Programmable basal rates introduced. Infusion sets improved.
2006	**OmniPod (tubeless):**	First patch pump. Revolutionized wearability; pod adheres to skin with no tubing.
2016	**MiniMed 670G:**	First FDA-approved hybrid closed-loop (HCL) system. Automated basal insulin delivery using CGM
2023–24	**iLet Bionic Pancreas & CamAPS FX:**	Fully automated closed-loop.

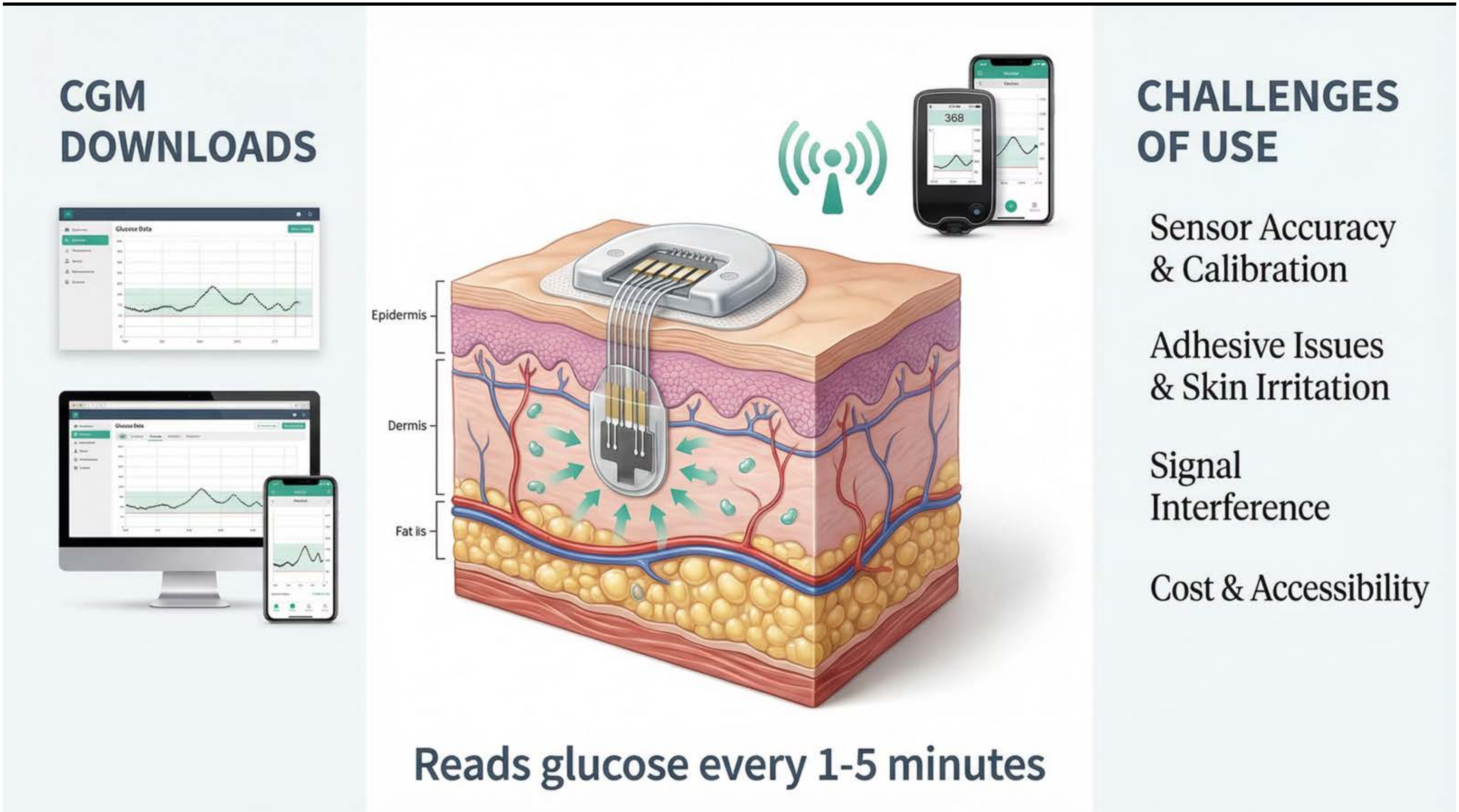
Pickup JC. Diabetes Care 2012;35:2611-2620. Diabetes Technol Ther. 2010;12(S1):S3-S12.

History of Continuous Glucose Monitoring

Decades of innovation

1967	**Updike & Hicks:**	Glucose oxidase electrode concept published. Theoretical basis for electrochemical CGM.
1975	**Clemens et al.:**	First 'artificial pancreas' — bedside glucose sensor + insulin delivery in closed loop.
1999	**GlucoWatch G2 Biographer (Cygnus):**	First FDA-approved wearable CGM. Reverse iontophoresis. Inaccurate, skin irritation — withdrawn 2007.
1999	**Medtronic MiniMed CGMS Gold:**	First retrospective CGM for clinical review. Blinded, 72-hour wear, downloaded by physician.
2006	**DexCom STS:**	First real-time CGM for patient use. 7-day wear. Required 2x daily fingerstick calibration.
2014	**Dexcom G4/G5:**	Share system introduced real-time remote monitoring. Follower app for caregivers/parents.
2017	**Abbott FreeStyle Libre (FSL):**	Flash glucose monitoring. No fingerstick calibration. 14-day wear. Factory calibrated.
2022–24	**Dexcom G7, Libre 3:**	One-piece, factory calibrated, 10–15 day wear

Rodbard D. Diabetes Technol Ther 2016;18(S2):S3. Klonoff DC. Diabetes Care 2005;28:1231-1239.


CGM
DOWNLOADS
Glucose Data
Glucose Data
Epidermis
Dermis
Fat iis
368
Reads glucose every 1-5 minutes
CHALLENGES
OF USE
Sensor Accuracy
& Calibration
Adhesive Issues
& Skin Irritation
Signal
Interference
Cost & Accessibility

How CGM Works: Technical Principles

Glucose in Interstitial Fluid → Glucose Oxidase Reaction → Hydrogen Peroxide Oxidation → Electrical Current Generated → Algorithm Converts to mg/dL

Filament Sensor

Platinum/iridium wire coated with glucose oxidase enzyme.
Inserted 5–7mm into subcutaneous tissue.

Transmitter

Sends glucose readings via Bluetooth every 1–5 minutes to receiver, smartphone, or insulin pump.

Interstitial-Blood Lag

5–15 minute physiologic lag between blood and ISF glucose.
Critical during rapid glucose changes.

MARD

Mean Absolute Relative Difference-CGM accuracy
Current CGMs: Dexcom G7 ~8.2%, Libre 3 ~7.8% (factory calibrated).

Heinemann L, et al. Diabetes Technol Ther. 2018;20(S2):S25-S54.

CGM Metrics & the Ambulatory Glucose Profile (AGP)

International consensus targets for time-in-range

Metric	Definition	Target (T1DM)
GMI	Glucose Management Indicator ≈ HbA1c	<7%
TIR	Time in Range 70–180 mg/dL	>70%
TAR L1	Time Above Range 181–250	<25%
TAR L2	Time Above Range >250	<5%
TBR L1	Time Below Range 54–69	<4%
TBR L2	Time Below Range <54	<1%
CV	Coefficient of Variation	<36%

Battelino T, et al. Diabetes Care 2019;42:1593-1603. Danne T, et al. Diabetes Care 2017;40:1631-1640.

Current CGM Devices: Clinical Comparison

Feature	Dexcom G7	Abbott Libre 3	Medtronic Guardian 4	Senseonics Eversense
Type	rtCGM	isCGM/rtCGM	rtCGM	Implantable
Wear Duration	10–15 days	14 days	7 days	180 days
Calibration	Factory	Factory	Required 2×/day	Monthly transmitter
Warm-up	~30 min	60 min	2 hours	N/A (implanted)
MARD	~8.2%	~7.8%	~9.0%	~9%
Pump Integration	Tandem t:slim X2	Not directly	MiniMed 780G	None currently
Cost/Month	~$300–350	~$75–90	~$300+	~$300 (after implant)

FDA device labeling 2024. Pickering TS, et al. Diabetes Technol Ther 2023. Senseonics prescribing information 2022.

How Insulin Pumps Work: CSII Fundamentals

Continuous subcutaneous insulin infusion

Insulin Reservoir
(U-100 rapid-acting)

Microprocessor
& Motor Drive

Infusion Tubing
(60–110cm)

Cannula/Infusion Set
(6–9mm subcutaneous)

BASAL INSULIN DELIVERY

- Programmed in units/hour (e.g., 0.8 U/hr baseline)
- Multiple basal rate programs possible (overnight, exercise, sick day)
- Mimics physiologic fasting insulin secretion

BOLUS INSULIN DELIVERY

- Standard (normal) bolus: rapid injection for meals
- Extended/square-wave: for high-fat/protein meals (gastroparesis)
- Dual-wave (combo): immediate + extended portions
- Correction bolus: calculated

Pickup JC, Keen H. NEJM 2002;347:1355-1360.

Current Insulin Pump Systems

Medtronic MiniMed 780G

Type: Advanced Hybrid CL

CGM: Guardian 4

Auto-correction boluses every 5 min; targets 100 mg/dL

Tandem t:slim X2 + Control-IQ

Type: Hybrid Closed-Loop

Predictive basal suspend, auto-bolus, sleep mode

Insulet OmniPod 5

Type: Hybrid Closed-Loop

Tubeless, smartphone-controlled, adaptive algorithm

iLet Bionic Pancreas

Type: Fully Automated

Weight-based dosing only; no I:C ratio or correction factor needed

Bergenstal RM, et al. NEJM 2021;385:1685-1695. Breton MD, et al. NEJM 2020;383:836-845.

Patient Selection Criteria: CGM

INDICATIONS

- T1DM — all patients (ADA Grade A)
- T2DM on intensive insulin (basal-bolus or pump)
- T2DM on sulfonylureas with hypoglycemia risk
- Hypoglycemia unawareness or history of severe hypo
- Gestational diabetes with insulin therapy
- HbA1c above goal despite standard monitoring
- Athletes and patients with variable glucose patterns
- Pre- and perioperative glucose monitoring (hospitalized)

CAUTIONS

✗ Skin allergy to adhesive/sensor material

✗ MRI compatibility

✗ Acetaminophen interference (Libre systems, older Dexcom)

✗ Poor dexterity/vision preventing transmitter changes

✗ Cognitive impairment without support

✗ Financial barriers — CGM costs $75–350/month

ADA Standards of Care 2026, Rec 7.15–7.17. AACE Consensus Statement on CGM 2022.

Patient Selection Criteria: Insulin Pumps (CSII)

Optimal candidates and factors that predict success or failure

PUMP CANDIDATES

T1DM inadequately controlled on MDI

Strong evidence; HbA1c ↓ 0.3–0.5%

Dawn phenomenon on MDI

Variable basal rates eliminate early AM hyperglycemia

Hypoglycemia unawareness

Automated suspend prevents severe events

Highly variable glucose (high CV)

Flexible basal rates reduce variability

Active lifestyle / athletes

Temporary basal rates during exercise

Frequent travel across time zones

No adjustments needed for schedule changes

Pregnancy (T1DM)

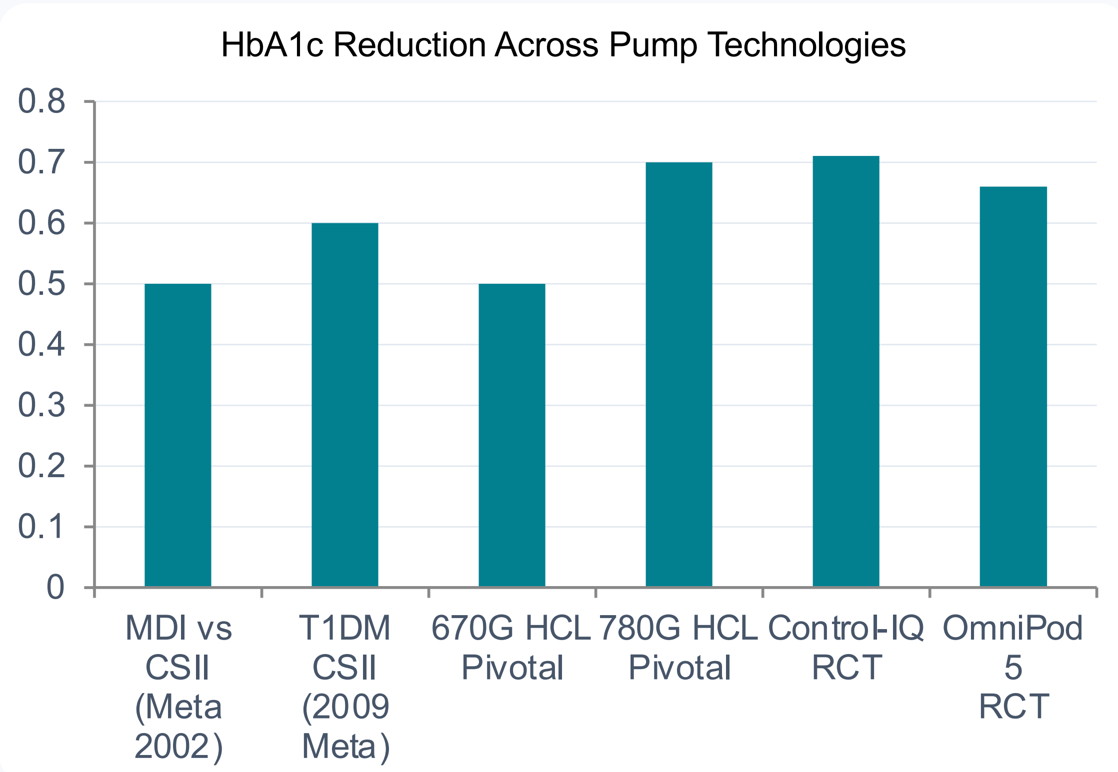
Tighter control achievable with pump + CGM

PREDICTORS OF PUMP FAILURE

- ✗ Poor self-management prior to pump initiation
- ✗ Inability to count carbohydrates
- ✗ Skin or adhesive reactions limiting site rotation
- ✗ Active eating disorder (DKA risk)
- ✗ Unrealistic expectations of 'automated' control
- ✗ Lack of trained support team (CDE)
- ✗ Social/economic barriers to supplies and follow-up

ADA Standards of Care 2026, Rec 7.25a–7.25b. Pickup JC. Diabetes Care 2012;35:2611. JDRF CSII Study. NEJM 2008;359:1464.

Evidence: Insulin Pump Outcomes



DKA hospitalizations

39% ↓ with pump vs MDI (Pickup 2014)

Severe hypoglycemia

4.2 → 0.7 events/patient-year (Control-IQ RCT)

Time in Range

+2.6 hrs/day with hybrid closed-loop vs MDI

Quality of Life

Pickup JC, et al. BMJ 2002;324:1. Yeh HC, et al. Ann Intern Med 2012;157:336. Bergenstal RM. NEJM 2021.

Automated Insulin Delivery: How It Works

CGM Sensor	Algorithm	Insulin Pump	Patient Input
Reads interstitial glucose every 5 min	Predicts future glucose trajectory	Adjusts basal ± correction boluses	Meal boluses announced (most systems)

✓ BENEFITS

- TIR improves 70–75% vs 60–65% with standard pump therapy
- 40–60% reduction in severe hypoglycemic episodes
- Dramatically reduced nocturnal hypoglycemia
- Decreased patient/caregiver decision burden
- ADA 2026: AID now PREFERRED over MDI and CSII

⚠ LIMITATIONS & CONSIDERATIONS

- Hybrid systems still require meal announcements and carb counting
- Learning curve: algorithms take weeks to adapt to individual patterns
- Technology dependence: requires reliable CGM data and pump function
- Cost and insurance access remain significant barriers

Bergenstal RM, et al. NEJM 2021. Breton MD, et al. NEJM 2020. ADA Standards 2026 Rec 7.25a, 7.27.

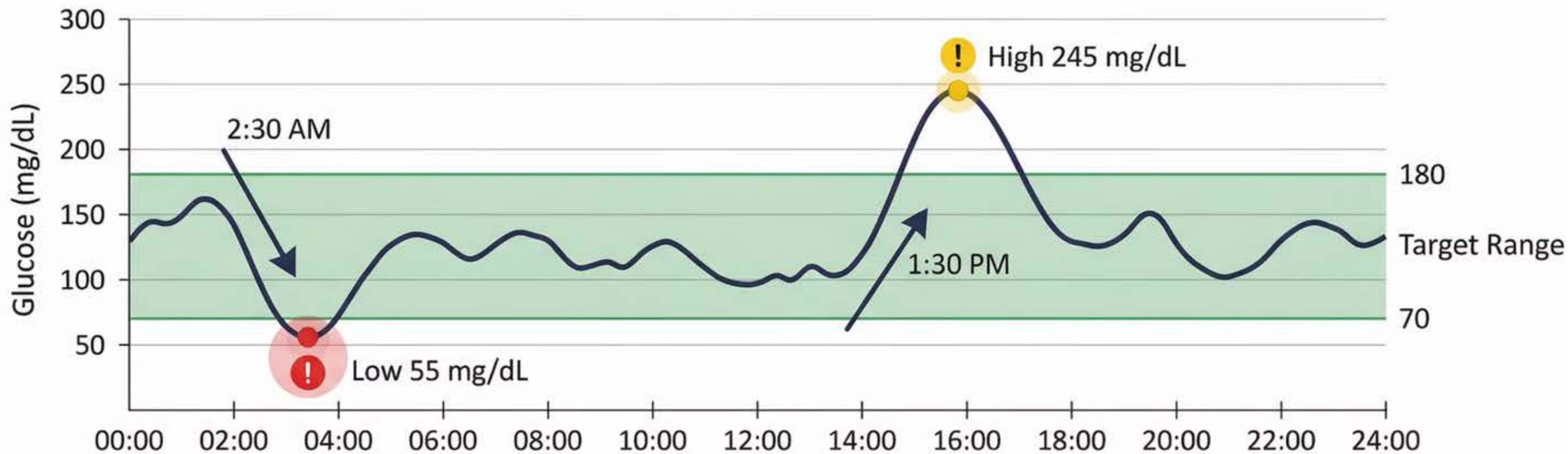
Misuses of CGM: Clinical Errors & Pitfalls

Common mistakes by patients, caregivers, and clinicians

PATIENT ERRORS	CLINICIAN ERRORS
! Treating ISF glucose lag as blood glucose — dosing insulin on dropping ISF reading when BG is rising	Using GMI interchangeably with HbA1c — GMI underestimates A1c by ~0.4% on average
! Ignoring trend arrows: treating a 140↓↓ the same as 140→→	Not reviewing AGP at clinic visits — defaulting to HbA1c alone
! Over-treating alarms: alarm fatigue leads to disabling critical alerts	Prescribing CGM without education on alarms, calibration, and trends
! Not confirming with fingerstick	Ignoring CV and TBR when TIR looks acceptable
! Applying sensor over tattoos or lipohypertrophy — potential inaccurate readings	

Klonoff DC, et al. Diabetes Care 2021;44:319-325. Fonseca VA, et al. Endocr Pract 2022.

CGM 24-Hour Glucose Trend Analysis & Challenges

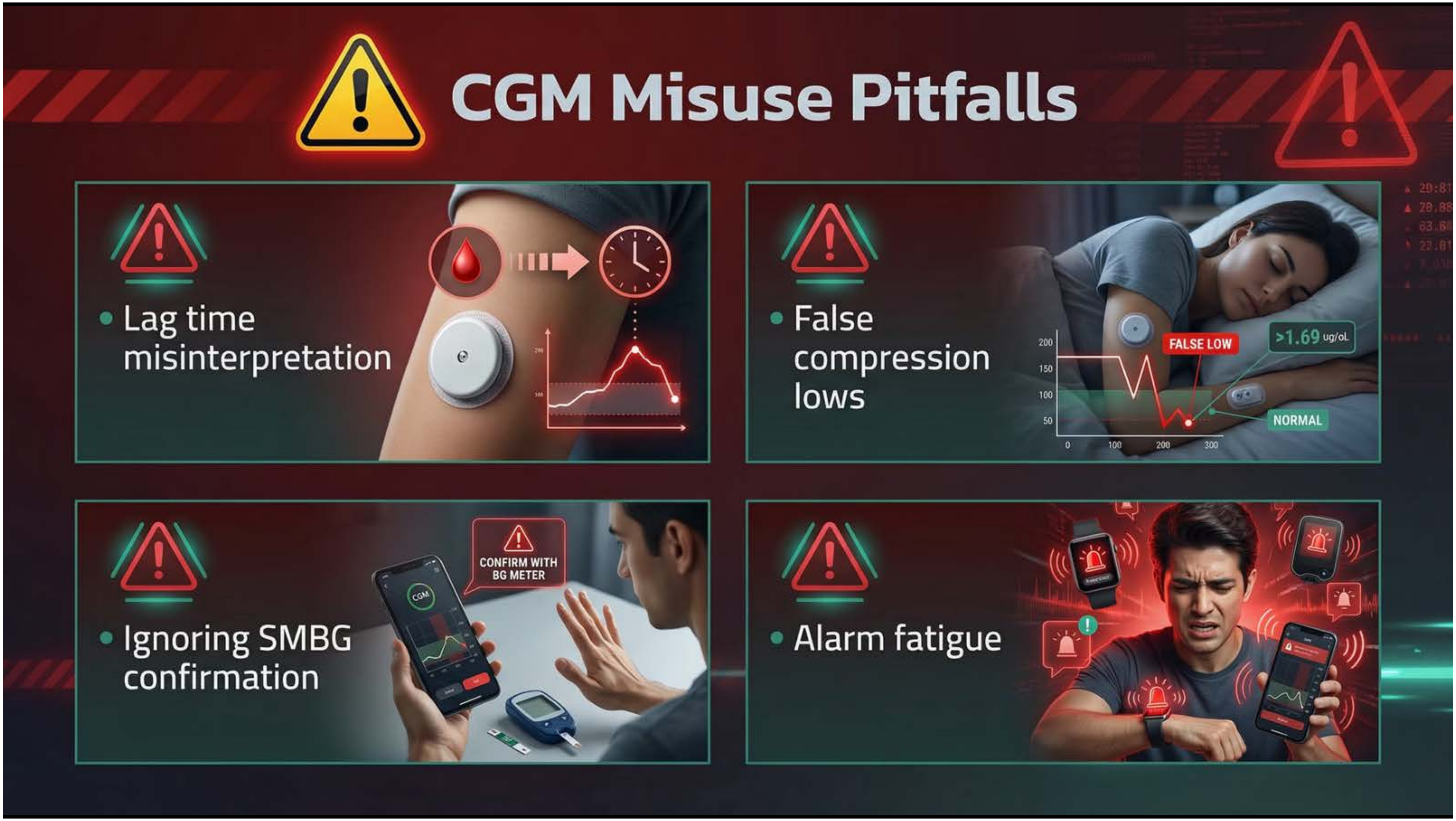


Data Overload & Interpretation

Too much data, hard to analyze

Sensor Accuracy & Discomfort

Skin reactions, signal loss


CGM Misuse Pitfalls
Lag time misinterpretation
False compression lows
FALSE LOW
>1.69 ug/oL
NORMAL
200
150
100
50
0
100
200
300
Ignoring SMBG confirmation
CONFIRM WITH BG METER
CGM
Alarm fatigue

Misuses of Insulin Pumps: Clinical Pitfalls

Pump-related errors are a significant cause of DKA hospitalizations

Infusion Set Occlusion

Most common cause of pump-related DKA.
No insulin delivered but alarm may not trigger immediately.

Risk of DKA within 4–6 hours.

Site Lipohypertrophy

Failure to rotate sites → fibrotic tissue → unpredictable insulin absorption.

Up to 52% of pump users have lipohypertrophy.

Always palpate infusion sites at visits.

Incorrect Carb Ratios / Correction Factors

Using outdated pump settings.
Insulin sensitivity changes with illness, weight, activity.

Annual or PRN review with certified diabetes educator

Forgetting to Reconnect After Disconnect

Showering, swimming, intimate activity.
Common in younger patients

Maximum safe disconnect: 1–2 hours.

Alarm Fatigue / Over-reliance on Closed loop

Trusting HCL system completely without understanding override situations.

System reverts to manual if Bluetooth lost, reservoir empty, or sensor errors.

Wrong Insulin Concentration

U-500 insulin in a U-100 calibrated pump = 5x overdose.

U-100 rapid-acting insulins.

Guilhem I, et al. Diabetes Metab 2006;32:279. Thalange N, et al. Arch Dis Child 2015;100:764.

Pump-Related DKA: Recognition & Prevention

RISK FACTORS FOR PUMP DKA	PREVENTION STRATEGIES
✗ Infusion set in >3 days without change	✓ Change infusion set every 2–3 days (max 3)
✗ Kinked/bent cannula or tubing	✓ Urine or blood ketone check when glucose >250 mg/dL
✗ Air bubbles in reservoir or tubing	✓ Sick day rules
✗ Insulin degradation (overheated pump)	✓ Keep backup insulin pens/syringes at ALL times
✗ Illness with increased insulin resistance	✓ Educate patient on 'pump vacation' protocol using MDI
✗ Issues with pump management	✓ Inspect site with every set change; rotate systematically

Kamrath C, et al. NEJM 2012;366:1679. Karges B, et al. Diabetes Care 2017;40:e64-e65.

CGM in the Inpatient / Hospital Setting

Does NOT replace POC for treatment decisions in critical illness, but reduces fingerstick burden.

ADVANTAGES

✓ Detects nocturnal hypoglycemia in sleeping patients

✓ Trend arrows enable proactive insulin dose adjustments

✓ Remote monitoring reduces patient room entries (infection control)

✓ Continuous data during procedures when periodic testing missed

LIMITATIONS

✗ Inaccurate with tissue edema, shock, vasopressors

✗ Interference from IV acetaminophen, dopamine (older models)

✗ Calibration required in ICU (G7 factory-calibrated helps)

✗ Technical staff training burden

✗ Not approved as standalone decision tool for insulin dosing

✗ Cost not universally reimbursed in inpatient setting

ADA Standards of Care 2026, Rec 7.29–7.30. Umpierrez GE, et al. Lancet Diab Endocrinol 2023;11:902. FDA 510(k) K213543 — Dexcom G7 Hospital Use.

Troubleshooting CGM: Clinical Scenarios

Practical approach to inaccurate readings and alarm management

Scenario	Action
CGM reads much higher than fingerstick *Causes: Sensor compression artifact, hyperosmolar state, malocclusion at site*	Action: Rotate sensor site. Confirm with calibrated fingerstick. If fingerstick normal and symptomatic, treat symptoms not sensor.
CGM reads much lower than fingerstick *Causes: Delay vs. rapidly falling BG. Paracetamol (acetaminophen) interference (older sensors)*	Action: Check 15 min later. Discontinue acetaminophen if possible
Constant LOW alarms, no symptoms *Causes: Sensor failure, poor site, compression (sleeping on sensor)*	Action: Confirm with fingerstick. If BG normal, restart sensor or replace. Rotate to new site.
Sensor warmup failure *Causes: Defective sensor, extreme temperature, expired sensor*	Action: Re-insert new sensor. Avoid application at <40°F or >104°F. Check expiration date.
Transmitter not connecting *Causes: Dead battery, Bluetooth interference, phone settings*	Action: Restart app. Ensure Bluetooth enabled. Replace transmitter

Freckmann G, et al. J Diabetes Sci Technol 2019. Dexcom G7 User Guide. Abbott LibreLink Professional.

Troubleshooting Insulin Pumps: Clinical Scenarios

Systematic approach to unexplained hyperglycemia and pump alarms

Unexplained hyperglycemia on pump	Step 1: Check reservoir — is insulin present? Step 2: Check infusion set — kinked? Air bubble? Site reaction? Step 3: Prime tubing and inspect cannula on removal Step 4: If BG >250 with ketones → inject correction via pen, change set, consider sick day protocol
Pump alarm: 'NO DELIVERY'	Indicates motor stall or high delivery pressure. Change infusion set and site immediately .Administer correction dose by injection. If alarm persists, call manufacturer helpline — pump may need replacement.
Auto-mode suspension (HCL)	HCL exits auto-mode when: CGM signal lost, glucose >300 mg/dL for >60 min, or sensor errors. Manually monitor BG. Resume auto-mode only when CGM signal restored and glucose trending down. Ensure backup supplies.
Site infection / abscess	Remove infusion set immediately. Review site rotation practices. Avoid sites with visible lipohypertrophy.

Walsh J. Pumping Insulin, 6th Ed. Klonoff DC. Diabetes Technol Ther 2020.

Access Barriers: Insurance, Cost & Equity

Disparities in CGM and pump access

Access to CGM and insulin pump technology is profoundly shaped by insurance coverage, socioeconomic factors, and systemic health inequities.

Since 2017 (therapeutic CGM)
CGM Coverage (Medicare)

Since 1999 (T1DM, qualifying criteria)
Pump Coverage (Medicare)

~80–90% (T1DM), varies T2DM
Private Insurance CGM Coverage

Highly variable by state
Medicaid CGM Coverage

RACIAL AND SOCIOECONOMIC DISPARITIES

Black and Hispanic youth with T1DM are 50–70% less likely to use CGM or insulin pump therapy despite equivalent clinical indication (Lipman et al., Diabetes Care 2013)

Physicians should proactively address cost, connect to patient assistance programs, and advocate for equitable prescribing.

Lipman TH, et al. Diabetes Care 2013;36:1633. NAM Report 2021. ADA 2024 Section 5.

Current Guidelines: ADA 2026 & EASD Consensus

Key recommendations from the 2026 ADA Standards of Care

ADA 2026 7.15	A	CGM recommended at diabetes ONSET and anytime thereafter for anyone on insulin, non-insulin therapies that cause hypoglycemia, or any treatment where CGM helps management [NEW 2026]
ADA 2026 7.25a	A	AID systems are the PREFERRED insulin delivery method over MDI, CSII, and sensor-augmented pumps in T1DM, T2DM on insulin, and insulin-deficient diabetes — no longer requires prior treatment steps [NEW 2026]
ADA 2026 7.25b	B	Consider AID systems for T2DM on basal insulin not achieving individualized glycemic goals — expanded eligibility [NEW 2026]
ADA 2026 7.27	B	Support and provide advice to people who choose open-source AID systems (e.g., Loop, AndroidAPS) — first explicit endorsement [NEW 2026]
ADA 2026 7.29	B	Continue personal CGM during hospitalization with confirmatory POC glucose for insulin dosing and hypoglycemia treatment, per institutional protocol
ADA 2026 7.30	C	Continue insulin pump or AID during hospitalization when clinically appropriate, with institutional protocols, trained personnel, and ongoing competency assessment
ADA 2026 6.3c	B	Goal TBR <70 mg/dL of <4% (or <1% for older adults); TBR <54 mg/dL of <1%. Deintensify therapy if these goals are not met.
EASD 2022	Strong	Offer CGM to all T1DM patients; HCL systems preferred over CSII alone when available and accessible

ADA Standards of Care 2026. Diabetes Care 2026;49(Suppl 1):S150-S179. EASD/ADA Consensus Report 2022. Diabetes Care 2022;45:2753-2786.

Clinical Workflow: Integrating CGM + Pump Data

How to efficiently review diabetes technology data at clinic visits

Step 1: Download AGP Report — 2 min

Access via Dexcom Clarity, LibreView, or Glooko. Review 14-day AGP pattern before seeing patient.

Step 2: Review TIR / TBR / GMI — 1 min

Is TBR >1% or >4%?
Hypoglycemia takes priority.

Is TIR <70%?
What time of day is glucose out of range?

Step 3: Review Pump History — 2 min

Download pump: review basal rates, total daily dose, bolus frequency, and IOB. Compare to carb intake history.

Step 4: Identify Pattern — 1 min

Overnight lows? Post-meal spikes? Mealtime omitted boluses? Use AGP modal day to identify consistent patterns.

Step 5: Adjust Settings — 3 min

Modify basal rate, I:C ratio, correction factor, target glucose, or insulin-to-carb timing based on pattern.

Step 6: Patient Education — 3–5 min

Reinforce site rotation, alarm response, sick day rules, and tech troubleshooting at every visit.

Kesavadev J, et al. Diabetes Technol Ther 2022. ATTD Yearbook 2024.

Patient Education Checklist: CGM & Pump Initiation

Minimum education requirements before technology initiation

CGM Initiation

- [ ] How to insert sensor correctly
- [ ] Understanding trend arrows and lag time
- [ ] Configuring alert thresholds appropriately
- [ ] When to confirm with fingerstick
- [ ] How to use the AGP report
- [ ] Recognizing and managing sensor errors
- [ ] Data sharing with caregivers/physicians
- [ ] Proper disposal of sensor waste

Pump Initiation

- [ ] Programming basal rates and boluses
- [ ] Carbohydrate counting fundamentals
- [ ] Infusion set changes every 2–3 days
- [ ] Site selection and rotation map
- [ ] Sick day protocol and when to switch to MDI
- [ ] Hypoglycemia treatment on pump
- [ ] Emergency insulin injection supplies always available
- [ ] Understanding HCL system limitations

ADA Standards of Care 2024. ADCES Practice Guidance 2022. Diabetes Technol Ther 2021.

Emerging Directions in Diabetes Technology

Fully Automated Closed-Loop

Zero user input required. iLet Bionic Pancreas (T1DM) — FDA approved 2023. Weight-based only. 3rd-gen algorithms eliminate carb counting.

Dual-Hormone Systems

Insulin + glucagon
Better hypoglycemia prevention.

Implantable CGM

Senseonics Eversense
Eliminates daily wearable changes.

Non-Invasive CGM

Spectroscopic methods (NIR, Raman, optical coherence tomography).

Apple Watch glucose sensing — multiple patents filed. Not yet clinically validated.

Artificial Intelligence

Predictive meal detection without carb entry.
Stress, illness, exercise recognition.
Personalized adaptive algorithms

Wearable Metabolite Panels

Multi-analyte patches: glucose + lactate + ketones + cortisol . (UC Berkeley, 2023).

Kovatchev B. Nat Rev Endocrinol 2022. Vettoretti M, et al. Sensors 2023. Ware J, et al. NEJM Evid 2022.

Case Study 1: The Over-Responding Patient

CASE PRESENTATION

A 28-year-old woman with T1DM (10 years) presents with HbA1c of 6.2% and reports 3–4 episodes of symptomatic hypoglycemia per week. She uses Dexcom G7 + OmniPod 5. She checks her phone "every 5 minutes" when an alert fires. She treats any reading <90 mg/dL with 15g carbohydrates regardless of trend arrow. Sleep quality: poor.

AGP REVIEW:

TIR: 82% ✓   TBR L1 (54–69): 9% ✗✗   TBR L2 (<54): 2% ✗✗   GMI: 6.5%   CV: 42% (high)

TEACHING POINTS

1. TBR >1% is the priority concern — not perfect TIR
2. Over-treating ISF readings without trend arrow context creates rebound hyperglycemia
3. Alarm fatigue: customize alerts (disable non-urgent), use CGM vibration only at night
4. Lower TBR by raising glucose target in OmniPod 5 to 120 mg/dL; reduce overnight basal 20%
5. Refer to diabetes educator for alarm management counseling and carb counting refresher

Hirsch IB. JAMA 2015;314:1624-1625. Nardacci EA, et al. Diabetes Educ 2011;37:55-73.

Case Study 2: The Pump Patient with Recurrent DKA

Infusion set misuse and site lipohypertrophy

CASE PRESENTATION

18-year-old male with T1DM since age 4, on MiniMed 780G + Guardian 4. Third DKA admission in 18 months. Each episode: glucose >500, bicarbonate <10. No infection identified. Pump shows no alarms prior to admissions. He reports 'the pump just stops working.' HbA1c has risen from 7.8% to 9.4% over 2 years.

PHYSICAL EXAM FINDING:

Bilateral periumbilical lipohypertrophy — firm, rubbery, non-tender plaques 8–12 cm diameter. Infusion sets always placed in same site.

CLINICAL MANAGEMENT & TEACHING

1. Root cause: lipohypertrophied tissue has markedly impaired/erratic insulin absorption — pump delivers dose but it pools subcutaneously
2. Management: mandatory site rotation map (8+ sites: abdomen quadrants, flanks, upper buttocks, lateral thighs)
3. Infusion set change every 48 hours
4. Guardian 4 sensor alerts for rapid glucose rise — patient had alarm disabled; re-enable
5. Structured pump education with CDE

Bergenstal RM, et al. Diabetes Care 2013;36:1. Heinemann L, et al. Diabetes Technol Ther 2014.

KEY TAKEAWAYS

01 ADA 2026: CGM is NOW recommended at diabetes onset — not just when control is poor. Earlier is better for all patients on insulin or at hypoglycemia risk.

02 ADA 2026: AID (automated insulin delivery) is the PREFERRED method over MDI and standard CSII

03 TIR >70% and TBR <1% are the primary CGM targets. CV <36% indicates acceptable glucose variability. GMI ≠ HbA1c — discordance requires investigation.

04 Pump-related DKA can develop within 4–6 hours. Educate patients on ketone monitoring, infusion set changes every 2–3 days, and backup injection protocol.

05 Site lipohypertrophy is underdiagnosed and drives insulin absorption failure. Palpate infusion sites at every clinic visit and enforce rotation.

06 Address health equity proactively. Technology disparities are real — connect patients to manufacturer assistance programs and advocate for equitable prescribing.

References

1. ADA Standards of Medical Care in Diabetes—2026. Diabetes Care. 2026;49(Suppl 1):S1-S321. [PRIMARY 2026 REFERENCE]
2. ADA Sec 7. Diabetes Technology: Standards of Care in Diabetes—2026. Diabetes Care. 2026;49(Suppl 1):S150-S179. Rec 7.15 (CGM at onset), 7.25a (AID preferred), 7.27 (open-source AID), 7.29-7.30 (inpatient).
3. ADA Sec 6. Glycemic Targets: Standards of Care in Diabetes—2026. Diabetes Care. 2026;49(Suppl 1):S128-S149. Rec 6.3c (TBR targets).
4. ADA Sec 16. Diabetes Care in the Hospital: Standards of Care in Diabetes—2026. Diabetes Care. 2026;49(Suppl 1):S339. Rec 16.7 (continue AID in hospital).
5. Summary of Revisions: Standards of Care in Diabetes—2026. PMC12690167. Diabetes Care. 2026;49(Suppl 1).
6. Battelino T, et al. Clinical targets for CGM data interpretation: recommendations from the international consensus on TIR. Diabetes Care. 2019;42(8):1593-1603.
7. Beck RW, et al. Continuous glucose monitoring vs fingerstick monitoring in adults with T1DM treated with MDI. NEJM. 2017;377(7):699-704.
8. Bergenstal RM, et al. Automated insulin delivery (Control-IQ) for T1DM. NEJM. 2021;385(18):1685-1695.
9. Breton MD, et al. A Randomized Trial of Closed-Loop Control in Children with T1DM. NEJM. 2020;383(9):836-845.
10. Danne T, et al. International consensus on use of CGM. Diabetes Care. 2017;40(12):1631-1640.
11. Doyle FJ, et al. Closed-loop artificial pancreas systems: engineering the algorithms. Diabetes Care. 2014;37(5):1191-1197.
12. EASD/ADA Joint Consensus Report. Management of T1DM with an Emphasis on New Technologies. Diabetologia. 2022;65:1853-1869.
13. Heinemann L, et al. Continuous glucose monitoring: an overview of technology and clinical use. Diabetes Technol Ther. 2018;20(S2):S25-S54.
14. IDF Diabetes Atlas, 11th Edition. International Diabetes Federation. 2023.
15. Klonoff DC, et al. CGM performance characteristics and quality of sensor accuracy. Diabetes Care. 2021;44(1):319-325.
16. Kovatchev B. Glucose Variability and CGM-Derived Metrics. Nat Rev Endocrinol. 2022;18:21-32.
17. Kristensen K, et al. CGM in pregnant women with T1DM: an RCT (CONCEPTT). Lancet. 2019;394:291-300.
18. Lind M, et al. Continuous glucose monitoring vs conventional therapy for T1DM. JAMA. 2017;317(4):379-387.
19. Lipman TH, et al. Racial and ethnic disparities in insulin pump use in youth. Diabetes Care. 2013;36(6):1633-1638.
20. Pickup JC. Insulin pump therapy for T1DM. Diabetes Care. 2012;35(11):2611-2620.
21. Pickup JC, Keen H. Continuous subcutaneous insulin infusion at 25 years. NEJM. 2002;347(18):1355-1360.
22. Rodbard D. Continuous glucose monitoring: a review of successes, challenges, and opportunities. Diabetes Technol Ther. 2016;18(S2):S3-S13.
23. Umpierrez GE, et al. CGM in the hospital setting: state of the art. Lancet Diab Endocrinol. 2023;11(12):902-912.
24. Wright LA, et al. Why is HbA1c discordant with CGM data? Diabetes Technol Ther. 2017;19(2):62-68.