Diagnosis and Monitoring Diabetes Mellitus

Facilitator Name & Title

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Objectives

- To be confident in determining an accurate diagnosis of type 2 diabetes.
- To be aware of the standards of care for type 2 diabetes.
- To identify the various methods required for the monitoring of type 2 diabetes.
- To explore how to interpret blood glucose results, trends and patterns.

**NB:** Throughout this presentation HbA$_{1c}$ may be displayed as % rather than mmol/mol if the referenced information was reported in this way.
Diabetes in the UK

• In 2018, Diabetes UK\(^1\) reported that there were 4.6 million people living with diabetes in the UK.
  – This includes 3.7 million diagnosed diabetes patients (65% increase over the decade). Therefore **around 1 million people with diabetes are undiagnosed**.

• **12.3 million people are at increased risk of Type 2 diabetes.**

• In 2016 Diabetes UK\(^2\) reported more than 24,000 people each year die prematurely because:
  – **Only 60% are receiving the 8 NICE recommended checks** to prevent complications.
  – Diabetes education courses are not being commissioned in over a third of England.
  – Hospital care is consistently below expected standard of care for diabetes patients.

• Of the £10 billion annually allocated to diabetes treatment, 80% is spent on treating complications associated with diabetes.\(^2\)

• **NHS Diabetes Prevention Programme** – joint commitment from NHS England, Public Health England and Diabetes UK to deliver (on a large scale) evidence-based behavioural interventions for those identified at high risk.\(^2\)

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Methods and criteria for diagnosing diabetes mellitus

**WHO diagnosis criteria:**

“HbA1c can be used as a diagnostic test for diabetes providing that stringent quality assurance tests are in place and assays are standardised to criteria aligned to the international reference values, and there are no conditions present which preclude its accurate measurement.

An HbA1c of 6.5% [48 mmol/mol] is recommended as the cut off point for diagnosing diabetes. A value of less than 6.5% does not exclude diabetes diagnosed using glucose tests.”

**Diabetes UK diagnosis criteria:**

**Diabetes symptoms** (e.g. polyuria, polydipsia and unexplained weight loss) **plus any one of the following:**

- A random venous plasma glucose concentration ≥11.1mmol/l.\(^2\)
- A fasting plasma glucose concentration ≥7.0mmol/l.\(^2,3\)
- Two hour plasma glucose concentration ≥11.1mmol/l two hours after 75g anhydrous glucose in an oral glucose tolerance test (OGTT).\(^2,3\)

Diagnosis continued…

With no symptoms, diagnosis should not be based on a single glucose determination but requires confirmatory plasma venous determination.¹

Diagnosis should be confirmed with at least one additional glucose test result on another day with a value in the diabetic range. This can be either:

- Fasting*
- A random sample*
- From the two hour post glucose load.

*If the fasting or random values are not diagnostic, the two hour value should be used.²

It is advisable to use one test or the other, but if both glucose and HbA₁c are measured and both are ‘diagnostic’ then the diagnosis is made. If one only is abnormal then a further abnormal test result, using the same method is required to confirm diagnosis.³

What is HbA$_{1C}$?

- **Glycated haemoglobin** (HbA$_{1C}$): the proportion of HbA$_{1C}$ to normal haemoglobin gives an index of glycaemic control over the preceding 2-3 months.\(^1\)

- HbA$_{1C}$ is formed by slow, non-enzymatic attachment of glucose to haemoglobin.\(^1\)

- **The normal reference range is around 20-42mmol/mol (4-6%).**\(^2\)

- Average HbA$_{1C}$ levels over longer periods (i.e. years) provide an estimate of the risk of **micro-vascular** complications.\(^1\)

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HbA$_{1c}$ should not be used to diagnose diabetes mellitus in the following groups:$^1$

- Children and young people (< 18 years of age).
- Pregnant women or women who are two months postpartum.
- People with symptoms of diabetes for less than 2 months.
- People at high diabetes risk who are acutely ill.
- People taking medication that may cause hyperglycaemia (for example corticosteroids).
- People with acute pancreatic damage, including pancreatic surgery.
- People with end-stage chronic kidney disease.
- People with HIV infection.

Impact of early glycaemic control

What is the ‘Legacy Effect’?¹

Among patients with newly diagnosed diabetes and 10 years of survival, HbA₁c levels ≥ 48mmols/mol [≥ 6.5%] for the first year after diagnosis were associated with worse outcomes.

Immediate intensive treatment for newly diagnosed patients may be necessary to avoid irremediable long term risk for diabetic complications and mortality.

Type 2 Diabetes: at risk?

**Impaired Fasting Glucose (IFG)**
Fasting plasma glucose between 6.1–6.9 mmol/l.¹

**Impaired Glucose Tolerance (IGT)**
Fasting plasma glucose < 7 mmol/l and an OGTT 7.8 – 11.1 mmol/l.²

The presence of IFG and/or IGT is known as

**Impaired Glucose Regulation (IGR) or non-diabetic hyperglycaemia (NDH)**³

*IGR and NDH* carry the highest risk for development of Type 2 Diabetes⁴

**High risk** is defined as a fasting plasma glucose level of 5.5–6.9 mmol/l or an HbA1c level of 42–47 mmol/mol (6.0–6.4%)⁵

If you are at risk of developing Type 2 diabetes, the *target HbA1c* should be below 42 mmol/mol⁶

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6. Diabetes UK. What is HbA1c?
Remission: ABCD and PCDS joint position statement on remission of Type 2 diabetes¹

**Discussion**
When in *remission*, how would you code your patients diabetes and conduct follow up?

- **Weight Loss**
  - < 48mmols/mol or fasting < 7mmols/l
  - 6 months apart

- **Remission**
  - All diabetes medication stopped

- **48mmols/mol or fasting < 7mmols/l**
  - 6 months apart

¹There is lack of consensus on the definition of remission nationally and internationally.

Monitoring can be categorised into broad topics

- Lifestyle Factors
- Blood Glucose Monitoring
- Symptoms
- Injection Technique
- Annual Screening
Monitoring diabetes control

In two groups, spend 3 - 5 minutes discussing:

“Why monitor?”

Healthcare Professionals’ Reasons

Patients’ Reasons
Why monitor? *Healthcare professionals’ reasons*

- To support the patient
- To assess blood glucose control.
- To assess effectiveness of treatment.
- To reduce risk of developing long-term complications.
- To help prevent deterioration of known complications.
Why monitor? *Patients’ reasons*

- To enable the individual to fit diabetes into their lifestyle.
- To help with planning of social activities.
- To reduce risk of acute complications.
- To slow the progression of complications.
In two groups, spend 3 - 5 minutes discussing:

What care should people with diabetes expect to receive in order to monitor their diabetes?
## Care Processes: What is standard care?

### Diabetes UK

**15 Annual Healthcare Essentials**

- HbA1c
- Blood pressure
- Cholesterol
- Retinal screening
- Foot examination
- Renal assessment
- Dietary assessment
- Emotional and psychological support
- Diabetes education
- Specialist care where required
- Flu immunisation
- Adequate hospital care when required
- Sexual dysfunction support
- Smoking cessation support
- Pre-Pregnancy Counselling

### NICE

**8 Annual QOF Care Processes**

- BMI
- Blood pressure
- HbA1c
- Cholesterol
- Record of smoking status
- Foot examination
- Albumin: creatinine ratio
- Serum creatinine measurement


2. NICE. Annual diabetes checks among indicators proposed for latest NICE QOF menu. Available at: [https://www.nice.org.uk/News/Article/annual-diabetes-checks-among-indicators-proposed-for-latest-nice-qof-menu][Accessed July 2020].
Symptoms

In groups spend 3 - 5 minutes discussing: ‘symptoms’ that may require monitoring and why

- Polyuria
- Polydipsia
- Nocturia
- Lethargy
- Weight gain or loss
- Hypoglycaemia
Lifestyle Factors

In groups spend 3 - 5 minutes discussing: lifestyle factors that require monitoring and why

- Blood Pressure
- Smoking
- Vaccines
- Weight
- Employment
- Psychological wellbeing
- Sexual dysfunction
- Dietary aspects
- Pre-pregnancy counselling
In groups spend 3 - 5 minutes discussing: typical annual blood tests you conduct for patients and why

- HbA1c
- Liver
- Thyroid function
- Renal (inc ACR)
- Coeliac (type 1 DM)
- Full blood count
- B12
- Cholesterol
Additional factors to consider that may affect glycaemic control
Insulin administration

Recap and Check!

- Injection technique
  - E.g. angle of needle entry,
  - how long to keep in the skin,
  - use of lifted skin fold,
  - mixing of cloudy insulins

- Injection site,
  - rotation habits

- Timing of injection

- Needle length

- Reuse of
In the presence of lipohypertrophy (LH)…

<table>
<thead>
<tr>
<th>Insulin users have LH</th>
<th>People re-use needles</th>
<th>People fail to rotate injection sites</th>
<th>Higher insulin doses are required</th>
</tr>
</thead>
<tbody>
<tr>
<td>64 %</td>
<td>70 %</td>
<td>25.4%</td>
<td>On average</td>
</tr>
</tbody>
</table>

Greater glycaemic variation
(compared with 7% in those without LH)
49 %

Occurrence of unexplained hypoglycaemia
(compared with 6% without LH)
39 %

Reduced and delayed insulin absorption and higher mean post-prandial blood glucose levels
26 %

Across studies, injection technique education and use of a 4mm needle led to a reduction in HbA₁c
Between 4.0 & 7.0 mmol/mol

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Limitations to using HbA\textsubscript{1c} as a monitoring tool

**Drawbacks to using HbA\textsubscript{1c}**

- Only reflects chronic hyperglycaemia with no correlation to acute glucose changes.
- Glucose variability is a better predictor of CVD compared to HbA\textsubscript{1c}.

**Some conditions increase or decrease HbA\textsubscript{1c}**:

- CKD
- Chronic alcoholism
- High Triglycerides
- Acute blood loss
- Sickle cell anaemia
- Thalassaemia

Thinking beyond HbA₁c: Time in Range

• HbA₁c is the ‘gold standard’ used to assess long-term complication risk from hyperglycaemia. But:
  – It cannot capture times spent in different glucose ranges, glucose variability or daily experience of a person’s glucose levels.
  – It cannot provide information on hypoglycaemia occurrence (yet this remains to be the biggest barrier to tight glycaemic control).

• Two people can have the same HbA₁c result but spend wildly different amounts of time at high and low blood glucose values.
  – E.g. HbA₁c of 53mmol/mol (7%) may reflect 100% time in range or just 18% time in range during the three month period.

• Consideration of ‘Time in Range’ allows individualised assessment of the person, including daily trade-offs that people make and key barriers to better outcomes.

Glycaemic profiles with the same HbA$_{1c}$ of 53 mmol/mol (7%)

1. The black line shows high variability with dangerous highs and lows.
2. The orange line shows moderate variability and fewer highs and lows.
3. The green line shows little variability with all time spent in-range.
   - The light green box shows the target blood glucose range.

Blood glucose monitoring
Blood glucose monitoring

• Determines blood glucose level at the time of the test.

• Gives opportunity to monitor trends and patterns in glucose levels.

• Some meters can be used to measure blood ketones.

• Results can assist in optimising treatment.

Who would you give a meter to?¹

- In groups spend 3 - 5 minutes discussing:
  
  a) Which patients would you supply with a blood glucose meter?
  
  b) Why?
  
  c) Would this be a temporary or permanent decision?

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Blood glucose monitoring in type 1 diabetes

Advise routine self-monitoring of blood glucose levels for all adults with type 1 diabetes, and recommend testing at least 4 times a day, including before each meal and before bed.

Support patients to test at least 4 times a day and up to 10 times a day if any of the following apply:

- The desired target for blood glucose control, measured by HbA\textsubscript{1c} level is not achieved.
- The frequency of hypoglycaemic episodes increases.
- There is a legal requirement to do so (such as before driving, in line with the Driver and Vehicle Licensing Agency [DVLA]).
- During periods of illness.
- Before, during and after sport.
- When planning pregnancy, during pregnancy and while breastfeeding.
- If there is a need to know blood glucose levels more than 4 times a day for other reasons (for example, impaired awareness of hypoglycaemia, high-risk activities).

1. © NICE. Type 1 diabetes in adults: diagnosis and management. NG17 2015, updated July 2016. Available at: https://www.nice.org.uk/guidance/ng17/chapter/1-Recommendations#blood-glucose-management [Accessed July 2020]

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Other technologies

- Ketone Monitoring
  - Ketones may be measured using urine or blood. Some meters may check both glucose and ketones. Access to ketone monitoring is variable.

- Flash Monitoring
  - Finger-prick-free system automatically measuring interstitial glucose levels via a small sensor attached to the upper arm.\(^1\)
  - Continuous glucose readings recorded and stored over 24 hours and up to 14 days. At each scan, the current glucose reading, and the last 8 hours of data (if scanned at least once every 8 hours), can be viewed.\(^1\)
  - An arrow indicates in which direction the glucose level is heading providing trends.\(^1\)
  - Small time delay, especially after eating or during exercise, means the result is not exactly the same as a capillary result.\(^2\)
  - A confirmatory finger-prick test should be conducted to support decisions for medication adjustments or treating a hypoglycaemic episode.\(^2\)
  - Software is available to support analysis and patterns in glucose levels providing data at times not normally available such as during the night.\(^2\)

Blood glucose monitoring in type 2 diabetes

Do not routinely offer self-monitoring of blood glucose for adults with type 2 diabetes unless:

• They are on insulin treatment.
• There is evidence of hypoglycaemic episodes.
• They are on oral medications that may increase their risk of hypoglycaemia while driving or operating machinery.
• They are pregnant, or are planning to become pregnant.

Consider short-term self-monitoring of blood glucose levels in adults with type 2 diabetes:

• When they are starting treatment with oral or intravenous corticosteroids.
  
Or

• To confirm suspected hypoglycaemia.

Frequency of testing

- Overall aim is to provide the most valuable information to the individual and healthcare professional.

- Number of tests must be decided in agreement with the individual.

- Consider pre and 1.5 – 2 hours post-prandial blood glucose monitoring.

- Group 2 drivers, treated with a sulphonylurea or another tablet with a risk of inducing hypoglycaemia should test blood glucose levels at least twice-daily and at times relevant to driving.¹

- Writing down glucose levels helps to visualise patterns and trends. Discovery sheets and glucose diaries are two resource examples.

Pre- and post-prandial monitoring helps patients to learn how lifestyle factors make an impact.
Pre and Post-prandial monitoring: Points to consider

**Aim:** Approx 5 – 7 mmol pre meal and 7 – 9 mmol post meal

2 - 3mmol/l rise in glucose post-prandially when compared to the fasting level

These parameters should be adjusted on an individualised basis¹

Considerations if the post-prandial rise is more than 2 – 3 mmol/l

- Was the carbohydrate portion eaten too large?
- Was the carbohydrate type too ‘sugary’ or did it have a high glycaemic index?
- Is the glucose lowering therapy administered inadequate for needs?

## Helping patients interpret their results

<table>
<thead>
<tr>
<th>Blood glucose before breakfast</th>
<th>Breakfast foods eaten</th>
<th>Blood glucose 1-2 hrs after breakfast</th>
<th>Blood glucose before lunch</th>
<th>Lunch foods eaten</th>
<th>Blood glucose 1-2 hrs after lunch</th>
<th>Evening meal foods eaten</th>
<th>Blood glucose 1-2 hrs after evening meal</th>
<th>Blood glucose before bedtime</th>
<th>Blood glucose before bedtime</th>
<th>Snacks</th>
<th>Exercise and general comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>8.10</strong></td>
<td>8.5</td>
<td>Weetabix + 2 cups of coffee</td>
<td>-</td>
<td>8.7</td>
<td>Piece of chicken + orange</td>
<td>7.9</td>
<td>6.1</td>
<td>16.5</td>
<td>9.1</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td><strong>9.10</strong></td>
<td>7.8</td>
<td>Weetabix + 2 cups of coffee</td>
<td>-</td>
<td>8.9</td>
<td>Small piece of chicken</td>
<td>8.9</td>
<td>6.8</td>
<td>13.2</td>
<td>10.6</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td><strong>10.10</strong></td>
<td>9.5</td>
<td>Weetabix + 2 cups of coffee</td>
<td>-</td>
<td>8.1</td>
<td>Roast chicken salad</td>
<td>9.2</td>
<td>8.1</td>
<td>8.3</td>
<td>7.3</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td><strong>11.10</strong></td>
<td>8.8</td>
<td>Weetabix + orange + banana + cup of coffee</td>
<td>12.4</td>
<td>-</td>
<td>Piece of chicken, greens, etc.</td>
<td>10.0</td>
<td>5.8</td>
<td>-</td>
<td>5.9</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td><strong>12.10</strong></td>
<td>6.1</td>
<td>Weetabix + banana + black coffee</td>
<td>15.9</td>
<td>10.2</td>
<td>Chicken breast, tomatoes, beetroot, cucumber, black coffee</td>
<td>7.2</td>
<td>5.3</td>
<td>6.8</td>
<td>6.5</td>
<td>Pear + orange (PM)</td>
<td>None</td>
</tr>
<tr>
<td><strong>13.10</strong></td>
<td>6.9</td>
<td>Weetabix + banana + black coffee</td>
<td>12.7</td>
<td>-</td>
<td>Cream crackers, cold meats, black coffee</td>
<td>8.7</td>
<td>8.1</td>
<td>6.9</td>
<td>6.8</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td><strong>14.10</strong></td>
<td>7.3</td>
<td>Weetabix + banana + black coffee</td>
<td>13.8</td>
<td>-</td>
<td>Cold meats, beetroot, cheese</td>
<td>8.9</td>
<td>5.6</td>
<td>7.1</td>
<td>-</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>
“91 – 97% of inaccuracies in monitoring results, are due to the skill of the user”¹

‘The User’

- Handwashing
- In date strips (including length of time in date once opened)
- Strip storage: temperature and ensure airtight
- Sufficient sample of blood
- Appropriate finger pricking device and technique
- Results should be in mmol/L (not mg/dL)
- Awareness of degree of meter error (esp. at low glucose)
- Awareness to re-check if result does not tally with symptoms
- Quality Control at home

‘The Meter’

- Meters should conform to International Organization for Standardization (ISO).
- ISO ensures:
  - Ease of use.
  - Safety.
  - Precision, accuracy and influence by abnormalities in haematocrit and other interferences.
- Haematocrit affects the fluid content of the blood, where the glucose is carried. Haematocrit abnormalities can result in erroneous results.
  - High haematocrit (e.g. chronic respiratory conditions, high triglycerides, shock, dehydration) can give falsely low BG readings (less fluid in the blood sample volume).
  - Low haematocrit (e.g. pregnancy) can give falsely high BG readings.

Enabling effective blood glucose monitoring

- Age 82
- Type 1 diabetes
- Frightened of hypos
- Tests 40-50 times per week

This case is fictitious and is only used for teaching purposes.
Enabling effective blood glucose monitoring

- Age 57
- Type 2 on insulin (basal bolus)
- Smokes heavily
- Unhealthy diet
- Tests 21 times per week
- HbA$_{1c}$ 107mmol/mol (11.9%)
Enabling effective blood glucose monitoring

- Age 36
- Type 2 on metformin
- Always been overweight/dieting
- Tests 4 times per week/post dietary treats!

This case is fictitious and is only used for teaching purposes.
Useful weblinks

• NICE impact diabetes.

• Diabetes UK: Your 15 diabetes healthcare essentials

• TREND UK: Blood glucose monitoring guidelines consensus document.

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Summary

• HbA$_{1c}$ is a recognised diagnostic method although may have limitations.

• Monitoring of diabetes is multi-faceted and standards of care exist.

• Blood glucose monitoring and discovery sheets are useful tools to support self diabetes management.